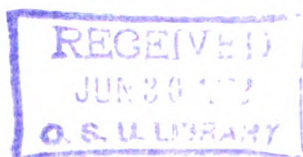


UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
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INFORMATION CIRCULAR

MULTIPLE-SHIFT MECHANICAL MINING IN SOME BITUMINOUS
COAL MINES. PROGRESS REPORT 1



BY

ALBERT L. TOENGES AND ROBERT L. ANDERSON

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COAL MINES. PROGRESS REPORT 1^{1/}

By Albert L. Toenges^{2/} and Robert L. Anderson^{3/}

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INTRODUCTION

The purpose of this paper is to describe some of the methods and practices of mining coal mechanically where more than one shift is worked, with the view of determining the advantages and disadvantages of various types of equipment and mining systems now in use. This paper is in the nature of a progress report, and, as the number of mines discussed in it is limited, the conclusions drawn in the comparison of various systems are not final but may be revised after subsequent investigations. Physical conditions vary in different and in the same mining districts and determine, more

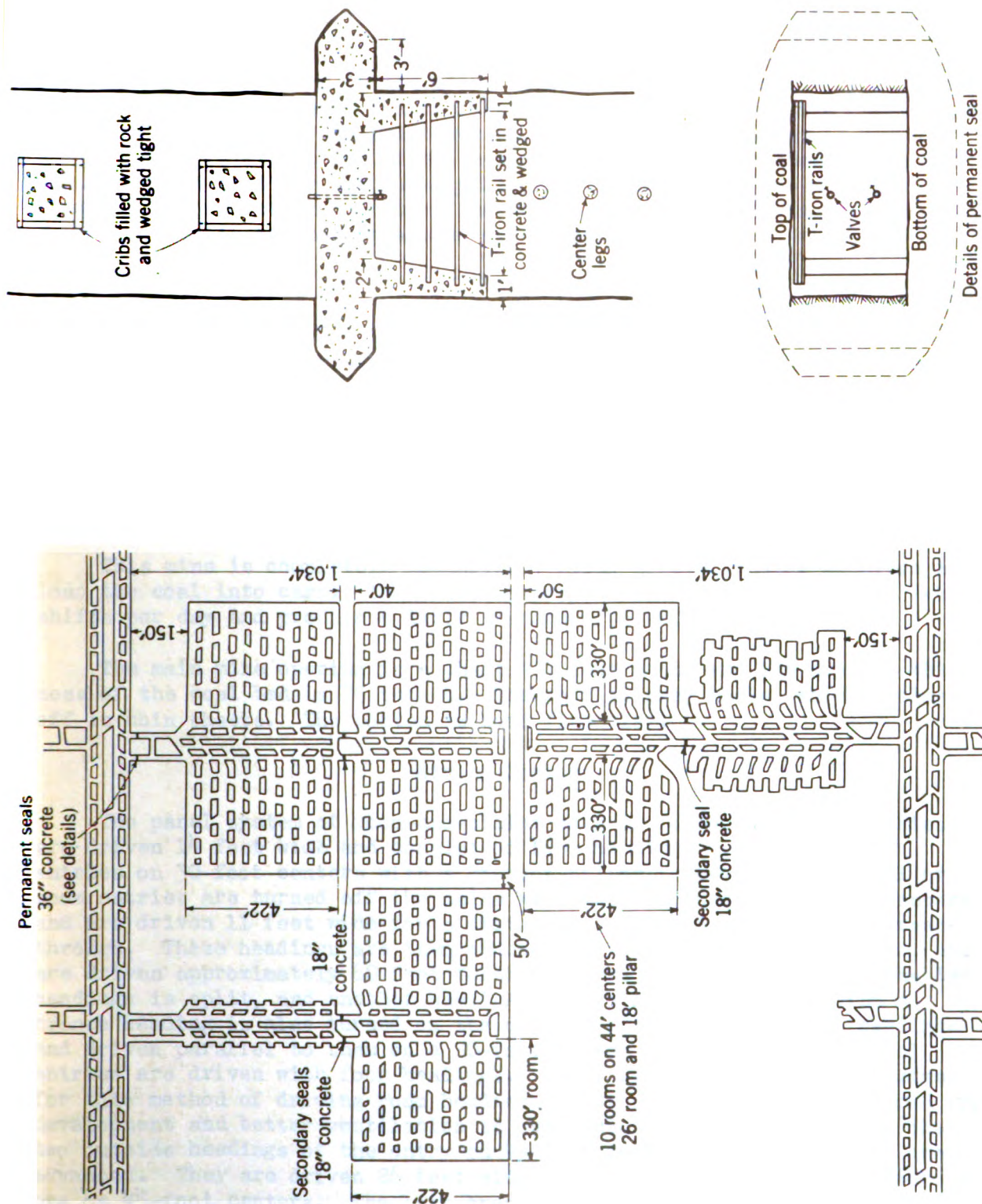


Figure 1.-Mining system at mine no.1.

or less, the system of mining and the type of mechanical loading equipment to be used. The information presented in this paper may be helpful to operators or others who may contemplate installing a mechanized mining system.

The equipment used in the mines described consists of conveyors, scrapers, mobile loaders, and combinations of these types. The description of the mining systems and practices at the mines investigated is detailed only as they relate to and affect mechanization. In computing the operating data in mines that are not totally mechanized, employees not working directly on production have been charged to output from mechanized sections in proportion to the percentage of mechanization.

ACKNOWLEDGMENT

The information used in preparing this paper was obtained through the courtesy and cooperation of the officials of the companies whose mines are described. The consent of each executive was obtained to publish the data and their accuracy was checked.

DESCRIPTION OF MINES

Mine No. 1

This mine is completely mechanized, using mobile loading machines that load the coal into cars. The mine and preparation plant operate two 7-hour shifts per day and produce a daily average of 5,200 tons.

The main mine opening is a shaft 432 feet deep, and the average thickness of the coal bed is 75 inches. The roof is gray shale, which scales off in thin sheets. The bottom is hard fire clay.

Mining System

The panel system of room-and-pillar work is followed. Main entries are driven 14 feet wide and consist of four headings or two pairs of entries on 30-foot centers with a 28-foot pillar between them. Panel or room entries are turned off the mains with two headings on 60-foot centers and are driven 11 feet wide for a distance of 60 feet to the first break-through. These headings are then widened to 14 feet, the usual width, and are driven approximately 60 feet farther, where the pillar between the two headings is split, and another heading is developed. At this point a branch heading is also turned on the outside of the two original headings and driven parallel to them on a 30-foot center line. Thus, the panel entries are driven with four headings. (Fig. 1.) The advantages claimed for this method of driving room headings are that more coal is produced from development and better ventilation is obtained. Rooms are necked on the two outside headings of the entry on 44-foot centers as the headings are advanced. They are driven 26 feet wide and 330 feet long and break-throughs are on 45-foot centers. The last break-through in the rooms is turned with special care, and it is exceptionally wide at the face of the rooms to

facilitate better ventilation. Pillars are not withdrawn. The plan of development followed is shown in figure 1. Following the completion of the inside 20 rooms (10 on each entry), secondary seals are constructed of 18-inch concrete. After the outside 20 rooms are completed the entire section is sealed with two permanent concrete seals. (See fig. 1.)

The mine track, which is 42-inch gage, is in the center of the working place. A row of props is placed 3 feet from each rail along the track on approximately 5-foot centers. One or two additional rows are set as needed on each side of the track. The place is timbered to within 12 feet of the face, which is the space required for operating the loading machine. Safety timbers are set as needed. Entries are timbered where roof conditions require it. Approximately 8 tons of coal are produced per prop.

The usual procedure in the cycle of operation is as follows: Cut, drill, shoot, timber, extend track, and load. These operations are continuous, and men are assigned and classified as to their respective duties and operations in the foregoing cycle, all of which are performed by a crew assigned to a loading unit. The number of men varies from 11 to 15, depending upon physical conditions and whether the crew is working in a narrow or wide place. An 11-man crew comprises the following:

- 2 cutting-machine men.
- 2 loading-machine men.
- 2 shooters, where airdox shooters are used.
- 2 drillers.
- 1 motorman.
- 1 trip-rider.
- 1 track-layer.

This number is the base, and timbermen, track-layers, or locomotive crews are added as needed. At the time the mine was visited, 10 units were in use on each shift.

Each unit has a shortwall cutting machine equipped with a 9-foot cutter bar. The cut is made in the coal at the bottom.

In sections where compressed air is used for blasting, the face is drilled with an electrically operated drill equipped with clawlike bits, which make a 4-1/2-inch-diameter hole. Five holes usually are drilled in a face and the compressed air-blasting crew follows the drilling crew. Four compressor units are in use, and on an average 60 holes are shot per shift per compressor.

Where permissible explosives are used, the holes are also drilled with an electrically operated drill, but the bit is the auger type, which makes a hole approximately 2 inches in diameter. These holes are charged and fired with fuse by shot-firers between shifts when no other workmen are in the mine. These places are then ready for the loading machines.

The ten loading machines are of the mobile type; nine are crawlers, and one is track-mounted. A gathering locomotive works with each loading machine to move empty and loaded cars. Track is placed in break-throughs and is used for car changes, reducing switching time to a minimum. The maximum switching distance is 150 feet where possible. Two locomotives are used to furnish cars for large-capacity loading machines. Following is an example of an average shift loading performance:

<u>Unit</u>	<u>Men</u>	<u>Cars loaded</u>
1	15	119
2	11	60 Narrow work
3	12	64 " "
4	12	60 " "
5	14	112
6	11	66 Narrow work
7	15	110
8	13	69 Narrow work
9	15	110
10	11	62 Narrow work
Total	129	832

A small loading machine is assigned 10 places and a large machine 20 places, ten on each of two headings. Cars have a capacity of approximately 3.5 tons.

A panel of 20 rooms usually is worked out in 60 days of two shifts each.

Gathering locomotives receive empties and return loads at partings or sidetracks placed near the working sections. Trips are taken by main-line locomotives to the shaft bottom, where the cars are hoisted on self-dumping cages and the coal is dumped and discharged to the preparation plant. All coal under 2 inches is rescreened by the rescreening plant and the refuse is crushed and washed.

The labor employed in a 24-hour period is as follows:

Classification	Day shift	Afternoon shift	Night shift	Total
<u>Underground:</u>				
Mechanical loading units	129	129	-	258
Main-line motormen	3	3	-	6
Main-line brakemen	3	3	-	6
Motor boss	1	1	-	2
Chief repairman	1	1	1	3
Repairmen	7	7	9	23
Main-line trackmen	2	-	-	2
Trapper	1	1	-	2
Pumper	1	-	-	1
Sump-cleaner	-	-	1	1
Fire boss	2	2	-	4
Airmen	8	-	-	8
Wiremen	2	-	-	2
Men sealing worked-out sections	4	-	-	4
Shot-firers	3	3	-	6
Laborers	-	-	10	10
Cager and blockers	2	2	-	4
Car-couplers	2	2	-	4
Supply men	2	1	-	3
Mine foremen	1	1	1	3
Section foremen	7	7	-	14
Safety engineers	1	1	-	2
Superintendent	1	-	-	1
Master mechanic	1	-	-	1
Total underground	184	164	22	370
<u>Surface:</u>				
Tipple	30	29	-	59
Blacksmiths	8	2	-	10
Hoisting engineer	1	1	1	3
Top boss and head flat trimmer	2	2	1	5
Wash house	1	-	-	1
Crane operator (transporting coal to power house)	1	-	-	1
Power house	2	2	2	6
Laborers	-	-	5	5
Total surface	45	36	9	90
Total all employees	229	200	31	460

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	5,200
Number of operating loading machines	10
Number of loading-machine shifts per day	20
Average number of men per unit per shift	12.9
Man-shifts per day on mechanized units	258
Average tons per day per man on mechanized units	20.1
Total number of employees underground	370
Average tons per day per man underground	14.1
Total number of employees, surface and underground	460
Average tons per day per man employed	11.3

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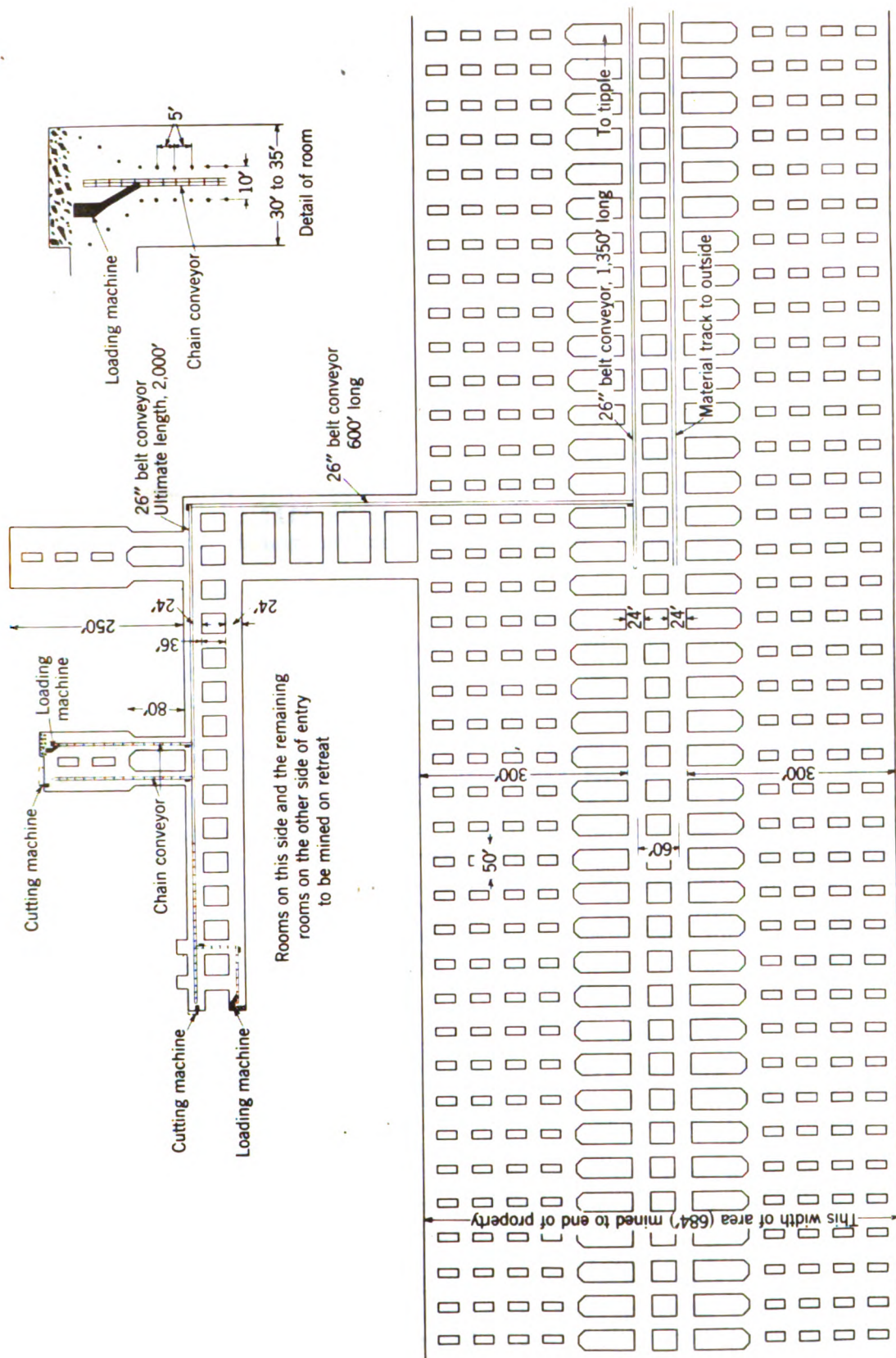


Figure 2.—Mining system at mine no. 2.

Mine No. 2

This mine is 100-percent mechanized and produces an average of 500 tons daily. The mine is opened in a coal bed that varies in thickness from 36 to 50 inches. In the present working places the average thickness is 42 inches. The roof is sandstone, except at places where there is a draw-slate, which varies in thickness from 0 to 18 inches. If possible, this draw-slate is held with timbers, but usually it must be taken down. The bottom is fire clay.

Mining System

The mine opening is a drift, and the room-and-pillar method of mining is employed.

Development work to the date the mine was visited consisted of a pair of headings driven across the property, a distance of about 3,600 feet. The first or outside portion of these headings will serve as the main entry throughout the life of the mine. As the headings advanced, rooms were turned at right angles from each heading. Rooms were driven 30 to 35 feet wide on 50-foot centers and 300 feet deep, and entries were driven 24 feet wide on 60-foot centers. (See fig. 2.) The entries were not brushed, and two belt conveyors were used for haulage. The first or outside belt was 1,350 feet long and the second or inside belt was about 2,000 feet long; the former is permanently located for the life of the mine, but the inside belt is moved as needed.

The present working area consists of a pair of headings 600 feet from and parallel to the development headings and having rooms turned off one heading only. The rooms are driven in pairs as needed to keep pace with the entry development, which usually allows for driving two rooms and omitting four. (See fig. 2.) When these entries reach the property limit (about 2,000 feet), rooms will be worked on the retreat. They will be turned off both headings and will be 250 feet deep. The width of pillars to be left between rooms (where they are to be driven on the retreat) has not been determined, but they will be made narrow enough to crush and allow the panel to cave.

The main haulage is a 26-inch conveyor belt that travels 200 feet per minute and has a capacity of 100 tons per hour. At the time the mine was visited, the belt was constructed in three sections. The first, which is permanently located, is 1,350 feet long and extends to the tippie; the second or lateral section is 600 feet, and the third section will eventually be about 2,000 feet. The travel of the first section is in one direction, but the lateral and third sections can be reversed for the purpose of carrying men and supplies to the inside of the mine. A track is built in the air course from the outside to a crosscut opposite the end of the first section of belt. Supplies and men travel on a car to this point, where a change is made to the belt. The grade of the track is 1 percent down toward the inside. Should increased travel become necessary due to greater

demand for supplies than at present, a small electric locomotive will be installed. The belt conveyor is constructed so that it can be extended in 100-foot sections. Coal is brought from the workings to the belt conveyor by gathering chain conveyors.

At the time the mine was visited, the working places consisted of two headings and two rooms off one heading. A small crawler loading machine, shortwall cutting machine, and an electric auger coal drill are used in each set of two places. A chain conveyor is laid in the center of each room, and mining operations are continuous. While a place is being prepared (timbered, cut, drilled, and blasted) the coal in the adjacent place is being loaded.

Two rows of timbers are set usually, one on each side of the chain conveyor (fig. 2), and safety timbers are set as required. Approximately 12.5 tons of coal are produced per pop.

Cutting is done in the coal on the bottom of the coal bed with shortwall cutting machines equipped with 6-1/2-foot cutter bars. After the cut has been completed, three holes are drilled, one at each rib and one in the center of the face. The holes are drilled 2-3/4 inches in diameter with auger drill with clawlike bits. They are charged with a permissible blasting device and fired electrically. An average of 60 blasting shells are used per day, and an average of 2.4 tons of coal is produced per pound of carbon dioxide, which is the blasting agent used in the shells.

The coal is loaded with the loading machine onto a room chain conveyor. This conveyor is built in 6-foot sections and is extended to within 8 or 10 feet of the face each time the face is advanced. The room conveyors from the various working places discharge to the main entry conveyor, and the coal is transported to the tipple.

The minus 2-3/4-inch coal is air-cleaned. The approximate percentage of sizes produced is as follows:

	<u>Percent</u>
Plus 5-inch lump	42.2
2-3/4- by 5-inch egg	14.0
Minus 2-3/4-inch	<u>43.8</u>
	100.0

Power is purchased from a public-utility company. Alternating current is used by all conveyor motors, and direct current, which is generated by a 150-kw rotary converter, operates the loading machines, cutting machines, and drills.

The men assigned to each mechanized unit do all the work necessary to get out the coal. They timber, cut, drill, blast, load, extend conveyor pans, and any other work required. All are paid a day wage. The labor for a 24-hour period is classified as follows:

Classification	Men	Crews	Shifts worked	Total men
<u>Underground employees:</u>				
Cutting-machine men	2	2	2	8
Loading-machine operator	1	2	2	4
Loading-machine helper	1	2	2	4
Face men	3	2	2	12
Driller and blaster	2	2	2	8
Laborers (midnight shift ¹) ..	2	1	1	2
Belt men ²	-	-	-	3
Foremen	1	1	2	2
Supervision	1	1	1	1
Repairmen	1	1	2	2
Total underground				46
<u>Outside labor:</u>				
Tipple	4	1	2	8
Blacksmith	1	1	1	1
Repairmen	1	1	1	1
Refuse disposal	1	1	1	1
Total surface				11
Total men				57

1/ These men deliver supplies and blasting shells and do other miscellaneous work.

2/ These men clean up spillage, grease, and do maintenance work on the main belts. Two work on day shift and one on night shift.

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	500
Number of loading machines	2
Number of loading-machine shifts per day	4
Average number of men per unit per shift	9.0
Man-shifts per day on mechanized units	36
Average tons per day per man on mechanized units	13.9
Total number of employees underground	46
Average tons per day per man underground	10.9
Total number of employees, surface and underground	57
Average tons per day per man employed	8.8

Mine No. 3

This mine, which operates three 7-hour shifts, is 100-percent mechanized and produces an average of 3,670 tons per day. It is opened in a coal bed averaging 60 inches thick and which contains three partings varying from 1/4 to 1-1/2 inches in thickness. Draw slate averaging 12 inches thick overlies the coal and usually is taken down by a crew of rock men. The roof is coal and shale and at places is difficult to hold. The bottom is hard shale.

Mining System

The mine opening is a drift, and the room-and-pillar system of mining is practiced. Both haulage and room entries are driven 8-1/2 feet wide, and the centers between haulage entries are 32 feet, but room entries are turned on 45-foot centers. Rooms are turned at a 60-degree angle from the entry and are driven 22 feet wide and 315 feet long. The center between rooms is 30 feet, leaving a pillar of 8 feet, which is not recovered. Development of entries is kept ahead of extraction, and room necks are turned by a crew assigned to this work. Generally, four cuts are taken in a room neck beyond the angle or V-cut made by the entry crew as the entry is advanced. Rooms are developed in blocks of twelve, on the advance in one entry and on the retreat in the other entry.

Four groups of 12-room units work simultaneously (for example, see fig. 3). Rooms are developed in blocks of twelve, off 17 W. and 20 W. entries on the advance and off 18 W. and 19 W. entries on the retreat. The first block of retreat rooms is started immediately after the fourth block of rooms is completed on the advance. When the rooms off these entries (17 W., 18 W., 19 W., and 20 W.) are completed, a 590-foot pillar is left (to be mined on retreat from the panel) and another group is started. Rooms off the east entries are worked in a similar manner until a panel approximately 3,900 feet by 3,500 feet is worked out. A pillar of coal equal to the distance between two rooms is left between blocks of twelve rooms. The roof usually breaks off at these pillars after the coal has been extracted from a block, and the break relieves the stress on the pillar, and prevents the weight of the overburden from riding over to the working block. A 115-foot barrier pillar is left between the first room off the room entries and the face entry. (See fig. 3.)

Mobile loading machines of the track-mounted type are used and the coal is loaded into cars. Nine machines are in use - five are working in rooms and four in narrow work (entries and room necks). The operations in the cycle are continuous, and the classification of men assigned to each crew is as follows:

Wide or room work:

- 1 - loading-machine operator
- 1 - loading-machine helper
- 1 - Motorman
- 1 - Brakeman
- 1 - Preparation man
- 5 - Stone men, who take down draw slate
- 1 - Tracklayer
- 2 - Drillers and shooters
- 2 - Timbermen
- 2 - Cutting machine men

17
Narrow work - entries and room necks:

- 1 - Loading-machine operator
- 1 - Motorman
- 1 - Brakeman
- 1 - Tracklayer
- 2 - Machinemen (also drill and shoot)

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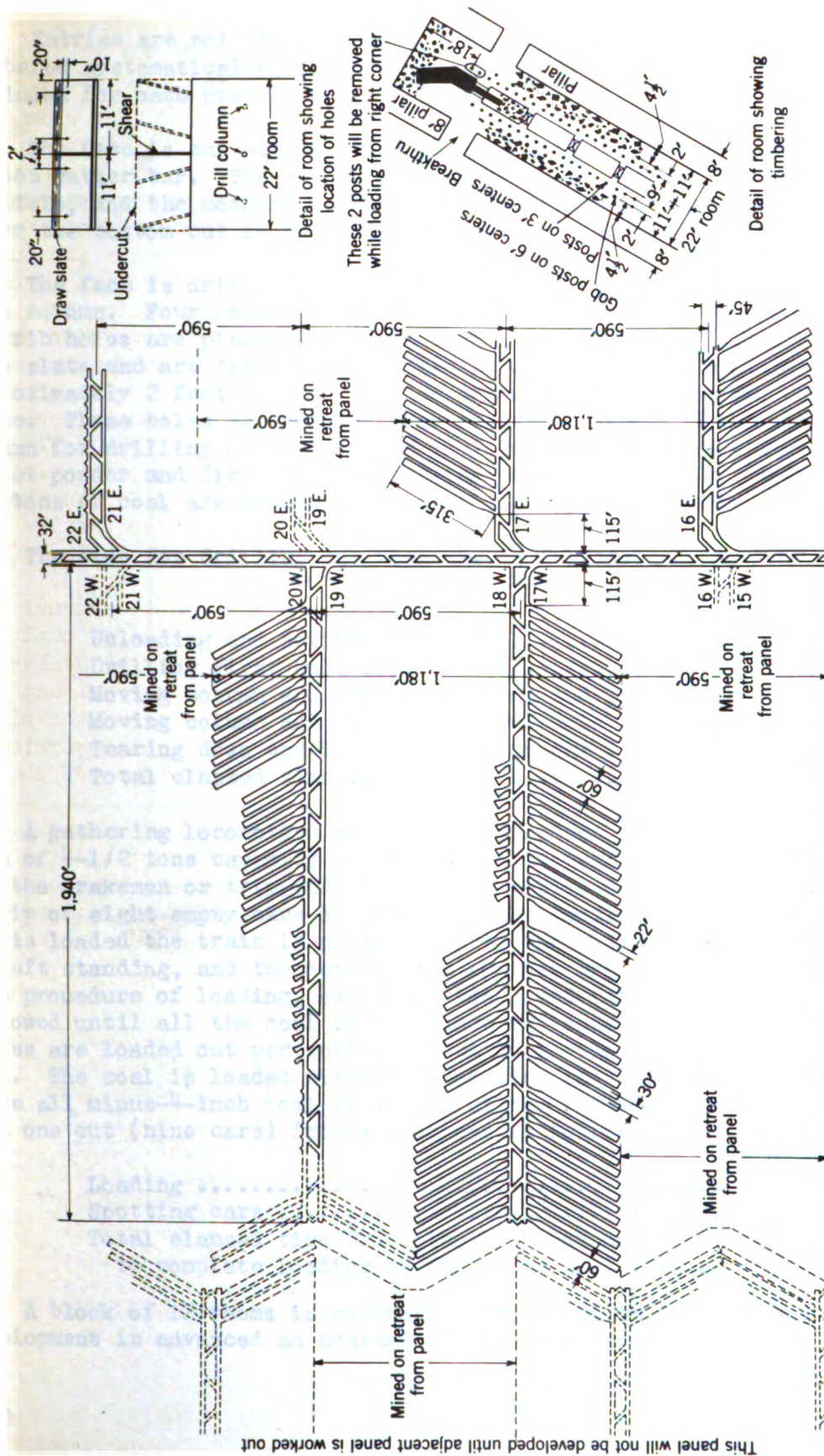


Figure 3—Mining system at mine no. 3.

Entries are not timbered except where necessary; rooms, however, are timbered systematically, as shown in figure 3. Approximately 4.9 tons are produced for each prop used.

The face is cut with a track-mounted cutting machine equipped with a 9-foot cutter bar. The cut is made in the coal as near the bottom as possible, and the machine is sumped at the right rib and cuts to the left. After the bottom cut is completed, the face is sheared in the center.

The face is drilled with an electrically operated auger drill mounted on a column. Four holes are drilled, two in each half of the sheared face. The rib holes are placed 20 inches from the rib and 10 inches below the draw slate and are drilled toward the rib. The center holes are drilled approximately 2 feet on each side of the shear and 10 inches below the draw slate. These holes are pointed away from the shear. The position of drill column for drilling holes is shown in figure 3. The holes are charged with pellet powder and fired with a blasting barrel and squib. Approximately 5.4 tons of coal are produced per pound of explosive used.

The time for drilling one room was as follows:

	<u>Minutes</u>
Unloading and setting up drill	3
Drilling first hole	3-1/2
Moving column and drilling second and third hole	7-1/4
Moving column and drilling fourth hole	5-1/2
Tearing down and loading drill on car	2
Total elapsed time	<u>21-1/4</u>

A gathering locomotive works in conjunction with a loading machine. Cars of 4-1/2 tons capacity are loaded at the end of the loading machine and the brakeman or trip rider regulates the loading of the car. Generally, a trip of eight empty cars is pushed to the loading machine, and as each car is loaded the train is pulled back to the entry, where the loaded car is left standing, and the rest of the empties are returned to the loader. This procedure of loading, switching load, and returning with empties is followed until all the coal in the place is loaded. From seven to eight places are loaded out per shift. A cut in a wide place averaged nine to ten cars. The coal is loaded without separating the impurities underground, since all minus-4-inch coal is washed at the tipple. The time required to load one cut (nine cars) from a room was as follows:

	<u>Minutes</u>
Loading	<u>24-1/4</u>
Spotting cars	<u>30-3/4</u>
Total elapsed time from placing first car to complete loading of ninth car	55

A block of 12 rooms is generally worked out in from 15 to 17 days, and development is advanced an average of 210 feet per week.

Draw slate is gobbled by the rock men, and timbers are set by timbermen, who are part of the loading crew. The working places are concentrated and closely supervised to eliminate lost motion.

The men employed during a 24-hour period are as follows:

Classification	Men	Crews	Shifts	Total
<u>Mechanical loading:</u>				
Wide places	17	4	3	204
Do.	17	1	1	17
Narrow places	6	4	3	72
Total men on loading equipment				293
<u>Day men:</u>				
Pumpmen				1
Wiremen				4
Bratticemen				3
Trackmen				11
Timbermen				12
Shopmen				8
Motormen	4		1/3	12
Trip riders	4		1/3	12
Dispatcher	1		3	3
Supply men	2		1/3	6
Recovering material				11
Allow 2 man-shifts for 15 hours overtime ..				2
<u>Supervision:</u>				
Section bosses	4		3	12
Mine foremen				4
				101
Total men underground				394
Total men surface				124
Total men employed				518

1/ 7-1/2 hours.

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	3,670
Number of loading machines	9
Number of loading-machine shifts per day	25
Average number of men per unit per shift	11.7
Man-shifts per day on mechanized units	293
Average tons per day per man on mechanized units	12.5
Total number of employees underground	394
Average tons per day per man underground	9.3
Total number of employees, surface and underground	518
Average tons per day per man employed	7.1

Mine No. 4

The mine opening is a drift and the average daily production of coal loaded mechanically is 2,550 tons, which represents 85 percent of the total production. The remaining 15 percent is loaded by hand. Mining operations are continuous, but the preparation plant works only one 7-hour shift.

The coal bed dips approximately 1-1/2 percent to the northwest, and an average section of the bed is:

	<u>Inches</u>
Coal	24
Middle band	12
Coal	36

The middle band is composed of bone, fire-clay, and laminated coal, and the thickness varies from 10 to 18 inches. The bottom part of the coal bed usually sticks to the bottom, which is shale. At places this shale is soft and has a tendency to heave, but usually it is hard and makes a smooth floor. The stratum above the coal is also shale, and as a rule it is hard and forms a good roof which requires little timbering. In some places, however, this shale is soft and has a tendency to fall in large slabs rather than to shear. Timbering is required where this occurs.

Mining System

A modified room-and-pillar mining system is used. Room panels are approximately 2,000 feet square, and barrier pillars protect the main entries. Room entries 20 to 22 feet wide on 50-foot centers are driven 2,000 feet long. Rooms are turned at right angles usually, off the heading only, on 80-foot centers. They are driven 22 feet wide and 300 feet long. The first rooms are turned at the face of entries, and after they have been driven to their length, 300 feet, pillars are withdrawn by the open-end method. Approximately 50 percent of the tonnage is from rooms and entries and 50 percent from pillars.

Little or no timber is required in rooms and entries, although posts are set where the roof has a tendency to slab. In pillar work, the system of timbering consists of two posts with a 12-foot cap, the sets being placed approximately 5 feet apart. An average of 17.5 tons is produced per prop.

Trolley locomotives are used for main-line haulage, and combination trolley and cable-reel locomotives gather the coal from face to sidetracks.

Description of Mechanized Operations

The cycle of operations is as follows: Tracklaying, cutting, slating, drilling, shooting, and loading.

All or some of these operations are performed throughout the 24-hour period. A crew is assigned to each type of operation, and the work period

is arranged to obtain maximum efficiency. Figure 4 shows the starting time of the various crews, all of which work a 7-hour day.

After a cut of coal has been loaded from a working place, the face is prepared for cutting and the track is extended to the face. Cuts are made in the middle band with a track-mounted cutting machine equipped with a 9-foot cutter bar. The kerf averages 5-1/2 inches, and since the entire middle band is removed the number of cuts depends upon the thickness of this middle band. From 11 to 14 places are cut in a 7-hour shift by each machine with a crew of two men.

Slating crews, usually consisting of six men, scrape the cuts and load or gob the cuttings of middle band.

After the cuttings have been removed the face is drilled by a crew of two men with a track-mounted drill. Six holes are drilled in a face - three above and three below the cut. A section of track is then removed and the holes are charged with permissible explosive, tamped with rock dust, and fired by means of electric detonators. Approximately 4.7 tons of coal is produced per pound of explosive.

Mobile loading machines mounted on crawlers are used to load the coal. The loading crew consists of an operator and helper and a motorman and brakeman, who place cars at the rear of the loading machine. A track turnout is placed in the break-through, which is usually not more than 90 feet from the face, and as the end car of the empty trip is loaded, it is placed on this turnout. When the trip (generally eight cars) has been loaded, it is taken to a side track or parting by the gathering locomotive and an intermediate locomotive takes it to the main parting, where it is assembled with other trips and transported to the tippie by a main-line locomotive. A timberman, who is also part of the crew, sets safety timbers as required. An average of 25 tons is loaded from each place, and on an average 8.33 places are cleaned up per loading machine shift. The following table shows performance of loading in a working place.

<u>Duty</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>
Loading, minutes	11.0	9.0	10.3
Car change, minutes	23.5	14.5	18.6
Delays, minutes	8.0	0.5	5.2
Total	42.5	24.0	34.1
Moving loader place to place, minutes	26.0	8.5	15.9
Cars loaded	9.0	8.7	8.9

There are eight loading machines, and these usually work 12 shifts per 24 hours. (Four machines are double-shifted.) Figure 4 shows an average schedule for each operation during a 24-hour period.

Mine employees chargeable to mechanized production for a 24-hour period are given in the following table. Where employees handle coal from both hand-loading and mechanized sections, the number charged to mechanized

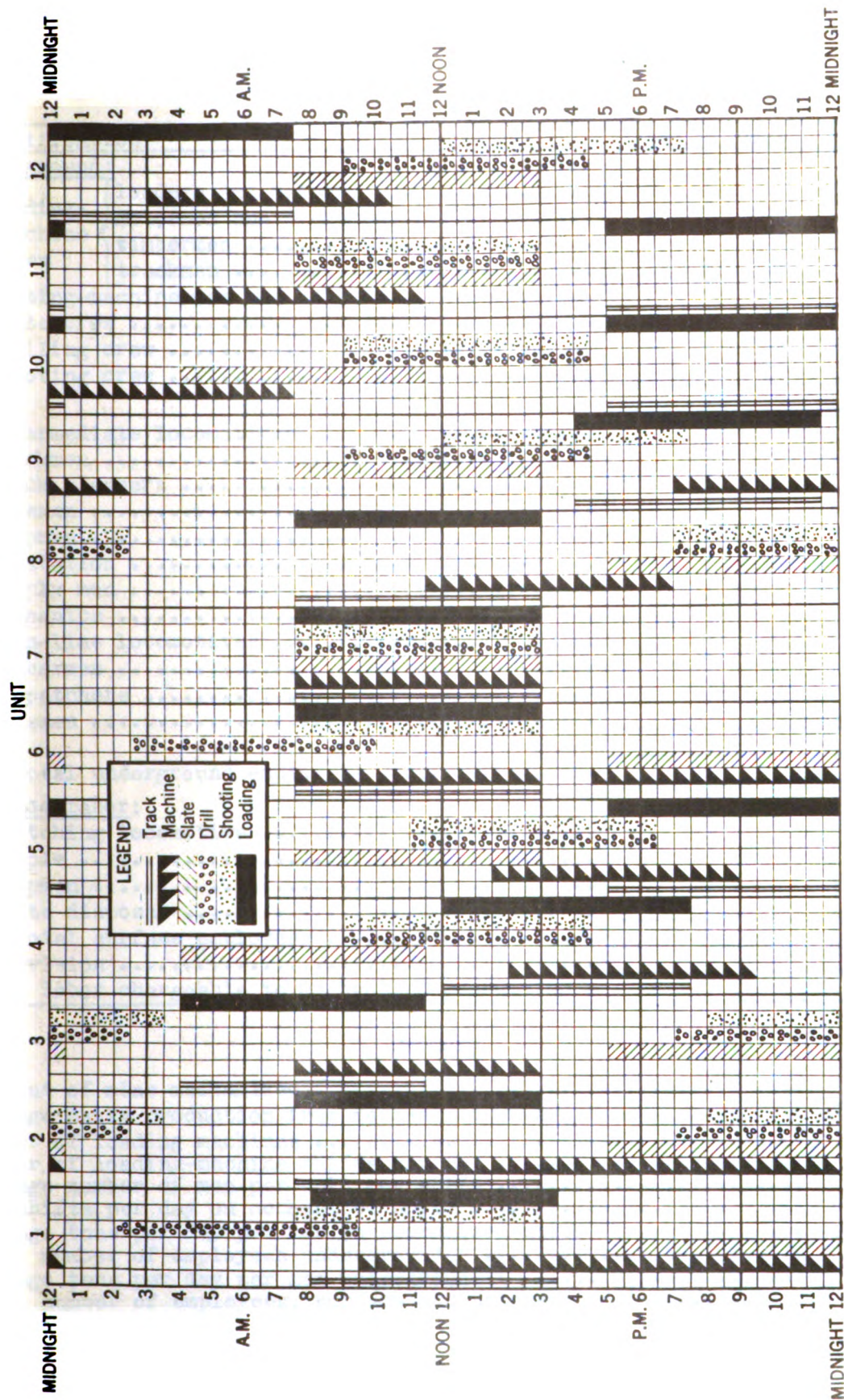


Figure 4.—Working schedule at mine no. 4.

production is prorated according to the ratio of this production to the total output of the mine.

Classification	Men	Crews	Total
Underground:			
Loaders and helpers	2	12	24
Machine motormen and brakemen	2	12	24
Timbermen	1	12	12
Trackmen	1	12	12
Cutting-machine men and helpers	2	12	24
Slate crew	6	12	72
Drilling crew	2	12	24
Shooting crew	1	12	12
			204
Intermediate locomotives			18
Trackmen			19
Track cleaners			5
Wiremen			6
Pumpmen			5
Substation			3
Supply men			2
Mechanics			2
Main-line locomotives			10
Timbermen			5
Dispatchers			2
Foremen			13
			90
Total underground employees			294
Surface labor:			
Switching locomotive			3
Tipple			34
Shopmen			18
Slate disposal			3
Total surface employees			58
Supervision			1
Total labor chargeable to mechanized production .			353

Summary

Percent of mine mechanized	85
Average daily production from mechanized units, tons	2,550
Number of loading machines	8
Number of loading-machine shifts per day	12
Average number of men per unit per shift	17.0
Man-shifts per day on mechanized units	204
Average tons per day per man on mechanized units	12.5
Total number of employees underground ^{1/}	294
Average tons per day per man underground ^{1/}	8.7
Total number of employees, surface and underground ^{1/}	353
Average tons per day per man employed ^{1/}	7.2

^{1/} Includes proportion of employees according to percentage of mechanization.

Tabular summary of figure 4.
24-hour period

	Number of men working on -							Number of machines		
	Track	Loading machines	Cutting machines	Slat-ing	Drill-ing	Shoot-ing	Total	Load-ing	Cut-ting	Drills
12:00-12:30 a.m.	8	20	8	27.5	6	3	72.5	4	4	3
12:30-1:00 a.m.	2	5	4	--	6	3	20.0	1	2	3
1:00-1:30 a.m.	2	5	4	--	6	3	20.0	1	2	3
1:30-2:00 a.m.	2	5	4	--	6	3	20.0	1	2	3
2:00-2:30 a.m.	2	5	4	--	8	3	22.0	1	2	4
2:30-3:00 a.m.	2	5	2	--	4	2	15.0	1	1	2
3:00-3:30 a.m.	2	5	4	--	4	2	17.0	1	2	2
3:30-4:00 a.m.	2	5	4	--	4	1	15.0	1	2	2
4:00-4:30 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
4:30-5:00 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
5:00-5:30 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
5:30-6:00 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
6:00-6:30 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
6:30-7:00 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
7:00-7:30 a.m.	4	10	6	11.0	4	1	35.0	2	3	2
7:30-8:00 a.m.	10	25	10	38.5	8	4	95.5	5	5	4
8:00-8:30 a.m.	12	30	10	38.5	8	4	102.5	6	5	4
8:30-9:00 a.m.	12	30	10	38.5	8	4	102.5	6	5	4
9:00-9:30 a.m.	12	30	10	38.5	16	6	112.5	6	5	8
9:30-10:00 a.m.	12	30	14	38.5	14	6	114.5	6	7	7
10:00-10:30 a.m.	12	30	14	38.5	12	6	112.5	6	7	6
10:30-11:00 a.m.	12	30	12	38.5	12	6	110.5	6	6	6
11:00-11:30 a.m.	12	30	12	38.5	14	7	113.5	6	6	7
11:30-12:00 noon	10	25	12	27.5	14	7	95.5	5	6	7
12:00-12:30 p.m.	12	30	12	27.5	14	9	104.5	6	6	7
12:30-1:00 p.m.	12	30	12	27.5	14	9	104.5	6	6	7
1:00-1:30 p.m.	12	30	12	27.5	14	9	104.5	6	6	7
1:30-2:00 p.m.	12	30	14	27.5	14	9	106.5	6	7	7
2:00-2:30 p.m.	12	30	16	27.5	14	9	108.5	6	8	7
2:30-3:00 p.m.	12	30	16	27.5	14	9	108.5	6	8	7
3:00-3:30 p.m.	4	10	10	--	10	5	39.0	2	5	5
3:30-4:00 p.m.	2	5	10	--	10	5	32.0	1	5	5
4:00-4:30 p.m.	4	10	10	--	10	5	39.0	2	5	5
4:30-5:00 p.m.	4	10	12	--	2	3	31.0	2	6	1
5:00-5:30 p.m.	10	25	12	27.5	2	3	79.5	5	6	1
5:30-6:00 p.m.	10	25	12	27.5	2	3	79.5	5	6	1
6:00-6:30 p.m.	10	25	12	27.5	2	3	79.5	5	6	1
6:30-7:00 p.m.	10	25	12	27.5	1	3	76.5	5	6	1
7:00-7:30 p.m.	10	25	12	27.5	6	3	83.5	5	6	3
7:30-8:00 p.m.	8	20	12	27.5	6	1	74.5	4	6	3
8:00-8:30 p.m.	8	20	12	27.5	6	3	76.5	4	6	3
8:30-9:00 p.m.	8	20	12	27.5	6	3	76.5	4	6	3
9:00-9:30 p.m.	8	20	10	27.5	6	3	74.5	4	5	3
9:30-10:00 p.m.	8	20	8	27.5	6	3	72.5	4	4	3
10:00-10:30 p.m.	8	20	8	27.5	6	3	72.5	4	4	3
10:30-11:00 p.m.	8	20	8	27.5	6	3	72.5	4	4	3
11:00-11:30 p.m.	8	20	8	27.5	6	3	72.5	4	4	3
11:30-12:00 mid-night	6	15	8	27.5	6	3	65.5	3	4	3

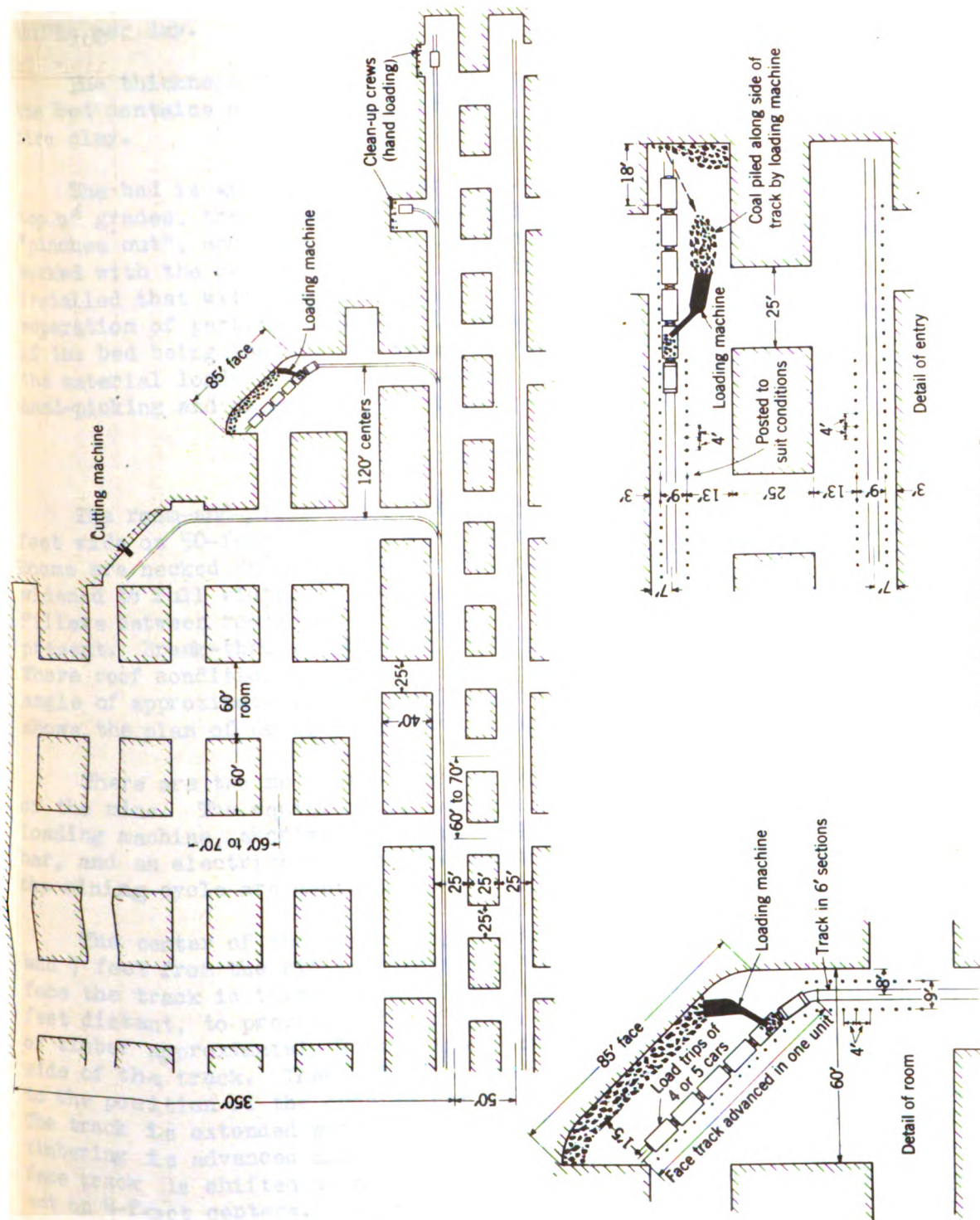


Figure 5.—Mining system at mine no. 5.

Mine No. 5

The average daily output of this mine, which is 100 percent mechanized, is 584 tons. Both the mine and preparation plant are operated two 7-hour shifts per day.

The thickness of the coal bed ranges from 44 inches to 67 inches, and the bed contains a number of partings. The roof is shale and the bottom is fire clay.

The bed is approximately level, but local changes in dip occur. At the top of grades, the portion of the bed below the middle band sometimes "pinches out", and when this occurs these areas of thinner coal cannot be worked with the present mechanical equipment. However, equipment is to be installed that will make it possible to mine a bed of this height. No separation of partings and coal is made in the mine, the entire thickness of the bed being loaded. In some places the impurities are 25 percent of the material loaded. Cleaning is done in the preparation plant both by hand-picking and washing. The stated production is the output of clean coal.

Mining Methods

The room-and-pillar system is used, and entry headings are driven 25 feet wide on 50-foot centers, with break-throughs on 60- to 70-foot centers. Rooms are necked 25 feet wide and are driven 40 feet. Then they are widened to full width, 60 feet, and driven their full length, 350 feet. Pillars between rooms are 60 feet wide and are not being withdrawn at present. Break-throughs between rooms are on 60- to 70-foot centers. Where roof conditions permit, the faces of the rooms are driven at an angle of approximately 45°, resulting in an 85-foot working face. Figure 5 shows the plan of development in a portion of the mine.

There are two mechanical units, each assigned to a separate section of the mine. The equipment of each unit consists of a mobile crawler type loading machine, shortwall cutting machine equipped with a 6-foot cutter bar, and an electrically operated auger drill. The several operations in the mining cycle are continuous.

The center of the track is approximately 8 feet from the rib in rooms and 7 feet from the rib in headings. Where rooms are worked on an 85-foot face the track is turned parallel to the working face and approximately 15 feet distant, to provide working space for the loading machine. Two rows of timber approximately 9 feet apart are set on 4-foot centers, one on each side of the track. They extend to the end of the track on the one side and to the position of the outside car on the other side to permit loading. The track is extended with each cut by inserting "jumper" rails, and the timbering is advanced also. The track is disconnected in rooms, and the face track is shifted as a unit the width of one cut and a row of timbers set on 4-foot centers. Other props are set where needed in the working place. (See fig. 5.) Approximately one prop is used for 4.0 tons of coal produced.

6430

The cut, which averages 5-1/2 feet deep, is made in the coal. The face is drilled above and below the middle band. In a 25-foot heading, five holes usually are drilled in the upper portion of the seam near the top and five below the middle band. From 18 to 20 holes are drilled in a 40-foot working place, and 25 to 30 holes in a 60-foot place, half of them above the middle band and half below it. The holes are charged with permissible explosive, tamped with clay stemming, and shot with fuse. An average of 3.5 tons of coal is produced per pound of explosive.

Trips of cars are set in the working place by a cable-reel locomotive, which works with the loading machine. The loading machine operates in the space between the track and the pillar side of the heading and between the track and face in rooms, loading cars from the side. To facilitate loading in headings, the coal is placed in piles at the rear of the machine and is reloaded into cars. Usually this is done when the loaded and empty trips are changed. Coal from break-through is handled similarly.

Since the track in rooms is parallel to the face, the coal is loaded directly into cars, four or five being loaded before they are switched. Figure 5 shows the loading arrangement in headings and rooms. Two hand loaders usually follow each loading machine to clean up road coal and spillage. These men are considered part of the loading crew. One loading machine loads from five to seven cuts per shift.

The gathering locomotives handle the trips from face to sidetracks, where they are assembled in 16-car trips and are transported by main-line trolley locomotives to the tipple. The main-line haul is approximately 2-1/2 miles.

Power is purchased from a public-utility company and is converted into direct current (for use on all underground units) by two 100-kw and two 150-kw motor-generator sets.

Classification	Men	Crews	Shifts	Total
Cutting-machine men	2	2	2	8
Loading-machine men	2	2	2	8
Clean-up men (hand-loaders)	2	2	2	8
Motormen	2	2	2	8
Timbermen	1	2	2	4
Trackmen	2	2	2	8
Drilling and shooting	2	2	2	8
Total employees with loading units..				52
Other underground employees:	<u>Day</u>	<u>Night</u>		
Motormen	3	3		6
Couplers	3	3		6
Trapper	1	-		1
Substation tender	1	1		2
Bratticemen	1	-		1
Trackmen	2	-		2
Mine foremen	1	1		2
Motor boss	-	1		1
Section foreman	1	-		1
Superintendent	1	-		1
Total other underground employees ..				23
Total underground employees				75
Surface employees:				
General outside labor	9	-		9
Tipple and washer	8	8		16
Total surface employees				25
Total employees				100

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	584
Number of loading machines	2
Number of loading-machine shifts per day	4
Average number of men per unit per shift	13.0
Man shifts per day on mechanized units	52
Average tons per day per man on mechanized units	11.2
Total number of employees underground	75
Average tons per day per man underground	7.8
Total number of employees, surface and underground	100
Average tons per day per man employed	5.8

Mine No. 6

Approximately 14 percent, 500 tons, of the total daily production of the mine is produced mechanically. Three shifts per day are worked in the mechanized section, but the preparation plant operates only one shift per day. The mine opening is a drift.

The coal bed averages 42 inches in thickness, and is free from partings. The roof is a shale, which requires close timbering, and at places draw slate 4 to 16 inches thick is present over the coal. The bottom is bone and fire clay. Local dips as great as 8 percent have been encountered.

Mining Methods

The room-and-pillar mining system is used (fig. 6). Entries are driven on 50-foot centers and are 20 feet wide. The roof of haulage headings is brushed 14 feet wide to a height of 5 feet 6 inches above the rail. Rooms are turned at right angles off both room entry headings on 41-foot centers and are driven 25 feet wide and 300 feet long. Break-throughs are made on 90-foot centers. One cut approximately 6 feet deep is taken off one side of the room pillar on the retreat, and, if possible, more coal is taken from the pillar if it can be obtained safely with the loading machine.

Room entries are not brushed; a main conveyor belt transports the coal from the room entry to the haulage entry, where the coal is loaded into cars. These room entries are driven approximately 2,000 feet long, and the first rooms are turned at the face of the entries. The main conveyor belt is 26 inches wide and is made up in sections so that it can be advanced or shortened in 204-foot lengths, and the frame that supports the conveyor is in 12-foot sections. The speed of the belt averages 275 feet per minute. At the time this mine was visited the main belt was 1,680 feet long.

As mining retreats, the length of the belt conveyor is shortened, and it generally requires the labor of 12 men for 48 hours to remove one section of conveyor (204 feet) and to move the feeder chain-conveyor ahead. If no bad roof is encountered, this move is made every six weeks.

Mobile-type crawler-mounted loading machines load the coal in the rooms onto chain conveyors, and it is transported to the 300-foot chain conveyor in the room entry. This chain conveyor, which gathers the coal from the rooms, discharges it onto the tail end of the belt. There are two rooms off each heading, and one loading machine loads from each pair of rooms in a continuous operation. Figure 6 is a plan of this method of operation.

The room conveyors are in 6-foot sections and are erected near the center of the room. A conveyor section is added with each cut advance of the face. The conveyor is kept 20 feet back from the face to permit loading with the loading machines. Draw slate, where present, is gobbled, and safety timbers are set where required. Timbers are placed at the end of the conveyor within 6 to 8 feet of the face on the side opposite the loading machine, as illustrated. An average of 4.2 tons is produced per prop.

Each room is equipped with a shortwall mining machine equipped with a 7-foot cutter bar. The cut is made in the coal immediately above the bone bottom. The face is drilled with an auger-type electric drill. Three holes usually are drilled, one at each rib and one in the center, starting 8 inches from the top and pointed toward the roof. The holes are charged with permissible explosives and are fired electrically. Approximately 10.9 tons of coal are produced per pound of explosive.

Four rooms have the following equipment:

4 cutting machines
2 loading machines
2 electric drills

A small electrically driven blower with flexible tubing is installed in the entry at each working place and furnishes auxiliary ventilation for the face.

The number of men chargeable to mechanized production in a 24-hour period is as follows.

Classification	Men	Crews	Shifts	Total men
Loading-machine operator	1	2	3	6
Loading-machine helper	1	2	3	6
Cutting-machine operator	1	2	3	6
Driller	1	2	3	6
Mechanic	2	2	3	3
Pan man	2	2	3	3
Timberman	2	2	3	3
Section foreman	2	2	3	3
Car trimmer	2	2	3	3
Total men in mechanized sections				39
Total other employees underground chargeable to mechanized production..				28
Total men underground chargeable to mechanized production				67
Total men surface chargeable to mechanized production				10
Total employees chargeable to mechanized production				77

Summary

Percent of mine mechanized	14
Average daily production from mechanized units, tons	500
Number of loading machines	2
Number of loading-machine shifts per day	6
Average number of men per unit per shift	6.5
Man-shifts per day on mechanized units	39
Average tons per day per man on mechanized units	12.8
Total number of employees underground ^{1/}	67
Average tons per day per man underground ^{1/}	7.5
Total number of employees, surface and underground ^{1/}	77
Average tons per day per man employed ^{1/}	6.5

^{1/} Includes proportion of employees according to percent of mechanization.

Mine No. 7

The average daily production of the mine is 400 tons, which is handled on conveyors. Both the mine and tippie operate two 7-hour shifts. The mine opening is a drift. An average section of the coal bed is as follows:

	<u>Inches</u>
Coal	4
Shale parting ...	2
Coal	43

There is usually a stratum of draw slate, which averages 12 inches thick, between the coal and the sandstone roof. This draw slate generally falls or is taken down. The bottom is fire clay.

Mining Methods

The mine is developed with a main entry consisting of four headings driven along the center of the property. Cross entries are turned at right angles off the main entry, and when they have been driven 150 feet the first room is turned at right angles off the headings. A 150-foot barrier pillar is left to protect the main entry. Rooms 20 feet wide are necked the full width on 50-foot centers. As the headings advance, rooms are developed off the inside heading. The rooms off the outside heading are worked on the retreat. The cross entries are driven 22 feet wide to the property line. The length of the rooms is 220 feet from the center line of the heading in which the belt conveyor is located. Break-throughs are made at 30-foot intervals from the right side of the rooms and are driven 20 feet wide and 30 feet long. They are turned as the face of the room is advanced. The 10 by 30-foot pillar between break-throughs is not recovered. Figure 7 shows a plan of part of the mine workings and the drive arrangement employed on the gathering belt conveyor.

The working faces consist of four rooms and a heading of the cross entry. Each working place is equipped with a shaking conveyor located in the center of the working place. Props generally are set on 6-foot centers, and there are two rows in each working place, one on each side of the conveyor. Safety timbers are set between the end conveyor pan and the face, as required, and an average of 11.0 tons of coal is produced per prop used.

The main conveyor belt, which is in the main entry, is 30 inches wide and 1,680 feet long. It operates at a speed of 140 feet per minute and is driven by a 15-horsepower alternating-current motor controlled by push buttons, one at the tippie and another inside the mine. The cross-entry or gathering belt conveyor, which feeds onto the main belt, is 24 inches wide and operates at a speed of 180 feet per minute. The drive for this gathering belt conveyor is also a 15-horsepower alternating-current motor. The driving arrangement is shown in figure 7. This drive motor also has push-button controls. Both belts are reversible and men and supplies are transported on them. The belt is made up in sections and can be extended

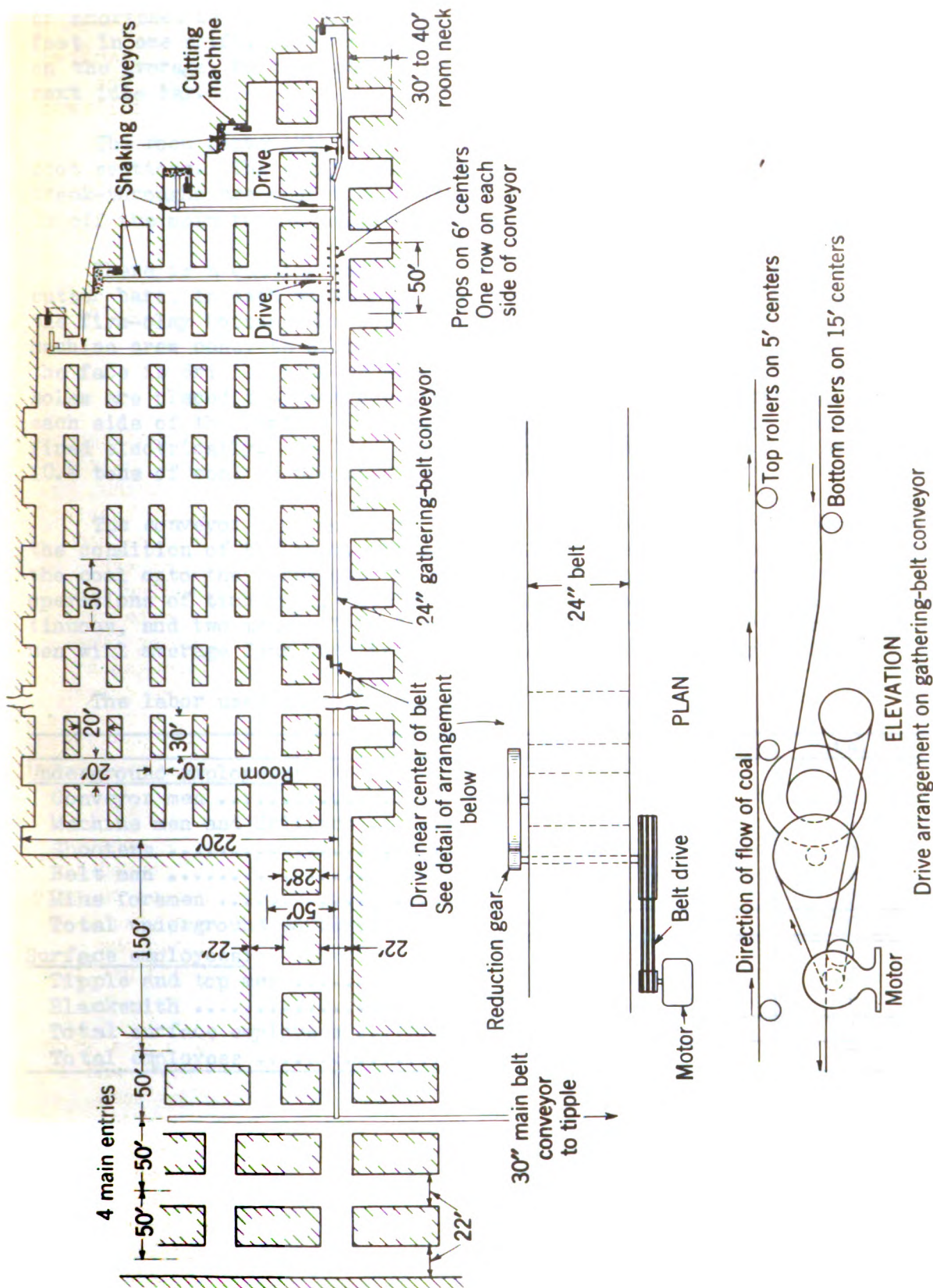


Figure 7.-Mining system at mine no. 7.

or shortened in 100-foot lengths. Two men extend or shorten the belt 100 feet in one shift. This is generally done once every week. Two rooms will, on the average, be completed every five days and the belt is moved on the next idle day.

The room conveyors, which are of the shaking type, are made up in 10-foot sections. The end pan is kept as close to the face as possible. When break-throughs are made the shaking conveyor is laid into it and the drive is off the main-room conveyor by means of a bell crank.

There is a cutting machine of the shortwall type, equipped with 6-foot cutter bars, in each working place. The cut is made about 2 inches above the fire-clay bottom, the bottom coal being left as a floor. The cutting-machine crew consists of two men, who also drill the coal. After cutting, the face is drilled with an electrically operated auger drill, and four holes are placed two feet down from the top, one at each rib and one on each side of the center. They are charged with permissible explosive and fired electrically. One man does the charging and firing. An average of 10.8 tons of coal is produced per pound of explosive.

The conveyor crew consists of two, three, or more men, depending upon the condition of the room. This crew timbers, extends the pan, and loads the coal onto the conveyor. Usually each crew has two working places. The operations of timbering, cutting, drilling, shooting, and loading are continuous, and two men will load an average of three cuts or a crew of three men will average four cuts from a 20-foot face in a 7-hour shift.

The labor used in a 24-hour period is as follows:

	Men	Shifts	Total
<u>Underground employees:</u>			
Conveyor men	14	2	28
Machine men and drillers	2	2	4
Shooters	2	2	4
Belt men	1	2	2
Mine foremen	1	2	2
Total underground employees			40
<u>Surface employees:</u>			
Tipple and top men	3	2	6
Blacksmith	1	1	1
Total surface employees			7
Total employees			47

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	400
Number of conveyor units	5
Number of conveyor-unit shifts per day	10
Average number of men per unit per shift	3.6
Man-shifts per day on mechanized units	36
Average tons per day per man on mechanized units	11.1
Total number of employees underground	40
Average tons per day per man underground	10.0
Total number of employees, surface and underground	47
Average tons per day per man employed	8.3

Mine No. 8

Average daily production of this mine, which is 100-percent mechanized, is 1,460 tons, and coal is hoisted on two 7-hour shifts. Development work is done on three shifts and the coal mined on the third shift is stored in cars and hoisted on the following day shift.

The coal bed averages 64 inches thick and dips approximately 3-1/2° to the northeast. There is a stratum of hard sandy shale 4 inches thick on top of the coal, and above this is a soft shale that disintegrates rapidly if the hard stratum is broken. Close attention is given to roof conditions, and systematic timbering is followed. The bottom is a soft shale.

Mining Methods

The mine opening is a slope and the mine is developed by the room-and-pillar system. Entries, which consist of two headings, haulageway, and air course on 50-foot centers, are turned off the slope an average of 300 feet apart. They are driven on the strike with about 1 percent rise in grade to facilitate haulage and drainage. The length of entries depends upon the width of the area to be mined, and they are driven to an established boundary before rooms are turned. Crosscuts are made from the lower heading, which is the haulageway, on about 60-foot centers. These crosscuts later serve as room necks. Rooms, which are worked in pairs (two rooms to an entry), are driven up the dip 25 to 30 feet wide and approximately 250 feet long from the air course with a 30- to 35-foot pillar between rooms, depending upon the character of the roof.

Shaking conveyors with self-loading heads, of which there are 12 units, are operated two shifts; four units are operated on the third shift in entries. Each unit consists of a shaking conveyor, shortwall mining machine equipped with an 8-foot cutter bar, an electrically operated auger drill, and a small blower fan connected to flexible tubing. One 3- or 3-1/2-ton trolley locomotive serves two units, and steel end-dump cars having a capacity of 3,500 pounds are used. Track gage is 30 inches.

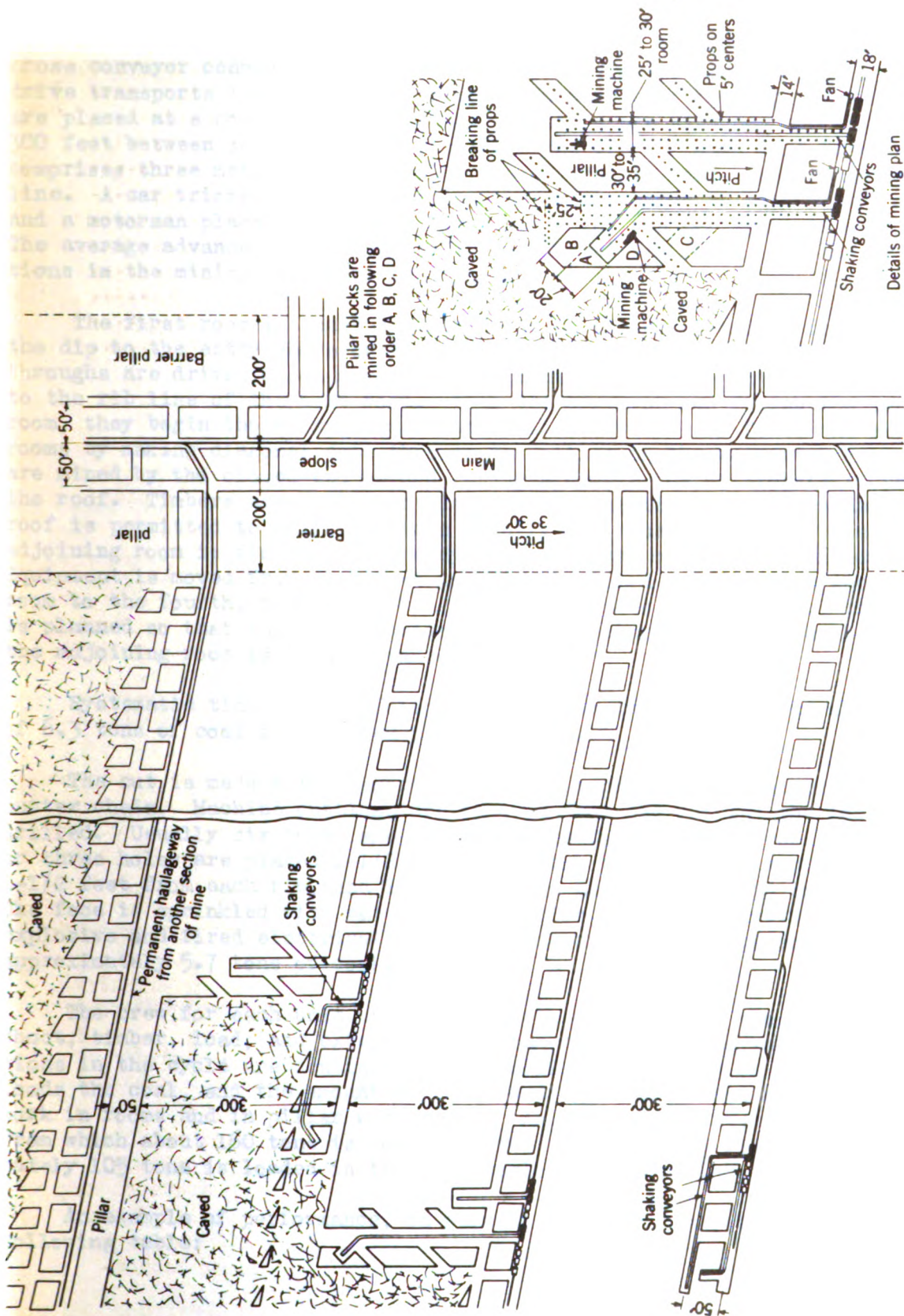


Figure 8.—Mining system at mine no.8.

Entries are driven with a shaking conveyor in each heading, and a cross conveyor connected to the conveyor in the upper heading with a side drive transports the coal from the upper to the lower heading, where cars are placed at a common loading point. Headings are advanced approximately 300 feet between set-ups. (See fig. 8.) The crew of each unit in a heading comprises three men, who cut, drill, timber, shoot, load, and extend pan line. A car trimmer works at the loading point common to both entry units, and a motorman places the cars. There are eight men per shift in each entry. The average advance per heading is 12 to 15 feet per shift, and the operations in the mining cycle are continuous.

The first room is started at the face of the entry and is driven up the dip to the entry above or to a barrier pillar along this entry. Break-throughs are driven at an angle to the right as the room advances and extend to the rib line of the next room. When the conveyor men finish the second room, they begin the extraction of the pillar between the first and second rooms by making diagonal cuts through the pillar on the retreat. Pillars are mined by the closed-end method, using a double row of timbers to break the roof. Timbers are pulled inside the breaking line of timbers and the roof is permitted to fall. Pillars usually are mined out by the time the adjoining room is finished and ready to start back on the next pillar. Equipment is moved from the first room to the third and from the second room to the fourth, thereby working only two places on an entry. The work is planned so that while the inside pillar is being withdrawn the face in the adjoining room is being advanced.

Systematic timbering is followed, as shown in figure 8, and an average of 6.3 tons of coal is produced per prop used.

The cut is made with a shortwall mining machine using water on the cutter chain. Machine cuttings are removed from the cut and the face is drilled. Usually six holes are placed in the face near the top, and two or three holes are placed 1-1/2 feet above the bottom - one approximately 1-1/2 feet from each rib, and if three holes are used, one in the middle. The face is sprinkled with water and the holes are charged with permissible explosive and fired electrically. One pound of explosive produces approximately 5.7 tons of coal.

The crew for each unit usually consists of four men, who cut, drill, shoot, timber, load, and extend pans of the conveyor. The various operations in the cycle are continuous. The self-loading head on the conveyor loads the coal, and the amount of hand loading is minimized both in advance work in rooms and in pillar extraction. An average of five cuts is made, from which about 160 tons is loaded in two shifts from a room, and approximately 105 tons is loaded in the same period from a pillar.

An example of performance, in percent of total time, is shown in the following table:

Total time (shift)	7 hours
Working place	Room
Size of working place	5 feet 6 inches high by 26 feet wide
Depth of undercut	7 feet 6 inches
Number of men at face	3
Number of men at loading head	1
Number of cuts loaded	2
Number of tons loaded	77

	<u>Percent of total time</u>
Cutting	30.8
Drilling and shooting	16.9
Extending conveyors	4.7
Timbering and dead work	5.3
Delays, waiting on cars, etc.	11.9
Loading	30.4
	<u>100.0</u>

An electric trolley locomotive serves two units. Partings or side-tracks are located in the haulageway at the slope and empties and loads are switched in trips of 14 cars to and from the sidetracks and units. The trips are transported from the sidetracks up the slope to the outside by an electrically operated hoist, whence they are hauled on the surface to the tipple.

The labor employed in a 24-hour period is as follows:

	No. men	Shifts	Units	Total
<u>Underground:</u>				
Conveyors:				
Rooms	4-1/2	2	8	72
Entries	4	2	4	32
Midnight shift	4	1	4	16
Additional labor account				
abnormal conditions	1	2	4	8
Machine boss	1	1		1
Total men - conveyor units				129
Other underground employees				37
Supervision				9
Total men underground				175
Surface, tipple and superintendence..				28
Total employees				203

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	1,460
Number of conveyor units	12
Number of conveyor-unit shifts per day	28
Average number of men per unit per shift	4.6
Man-shifts per day on mechanized units	129
Average tons per day per man on mechanized units	11.3
Total number of employees underground	175
Average tons per day per man underground	8.3
Total number of employees, surface and underground	203
Average tons per day per man employed	7.2

Mine No. 9

The average daily production from the mechanized sections of the mine is 1,045 tons, which is approximately 75 percent of the total. Underground operations are conducted on three 7-hour shifts, but the preparation plant operates only 14 hours per day.

The average thickness of the coal bed is 52 inches and the bed contains a number of shale partings. Draw slate averaging 12 inches thick is present over the coal and is generally taken down in entries and room necks, but timbers are used to support it in rooms. The bottom is fire clay.

Mining Methods

The mine opening is a drift and the room-and-pillar system of mining is used. Side and room entries are driven 10 feet wide on 32-foot centers. A 4- to 6-foot slab is taken on retreat off the rib side of the haulage heading of the room entry, and the gathering conveyors are placed in this space. The room entries are driven to their limit, and rooms are turned on the retreat off the haulage heading; extraction of the coal is toward the side entries, leaving a 200-foot barrier pillar for their protection. Rooms are 50 feet wide with a 17-foot pillar between rooms. They are driven 300 feet long to the air course of the next room entry. The method of development is shown in figure 9.

Mechanization consists of hand-loading on shaking and chain conveyors. Each working place is equipped with a conveyor. The conveyors are arranged in sets of two or four and discharge to a gathering conveyor, which transports the coal to an elevating conveyor. The arrangement of the conveyor in these two systems is shown in figure 9. Four 2-room units and one 4-room unit are in operation. The elevating conveyors discharge the coal into cars, which are spotted with a small electric hoist by the loading-head man. Loaded trips are taken to a sidetrack or parting by a gathering locomotive, and thence to the preparation plant by trolley locomotives.

A shortwall cutting machine equipped with a 5-1/2-foot cutter bar is kept in each working place. Face crews work between two places in both

the two-room and the four-room units, and the various operations in the mining cycle are continuous.

The crew of a two-room unit is as follows:

6 loaders
1 machineman
1 boom or loading-head man,

and the crew of a four-room unit is:

12 loaders
2 machinemen
1 boom or loading-head man.

One loader of each crew sets timbers and one serves as a cutting-machine helper.

Entries are driven as a two-room unit, six men working between the two headings. This crew will advance a 10-foot entry an average of two cuts per shift.

A row of timbers is set on each side of the room and face conveyors, usually on 5-foot centers, and along the face, as needed, on 4- to 6-foot centers before shooting. (See fig. 9.) Approximately one prop is used for 4.5 tons of coal produced.

Machine cuttings are loaded out before the face is drilled. A hand-operated auger drill is used, and generally four holes spaced on 10-foot centers are drilled in the face. The side holes are started 10 feet from the rib and pointed toward it, and the two center holes are drilled parallel to the rib.

Before the face is shot, the timbers are moved and the face conveyor is shifted to within two feet of the face, and then the timbers are reset. The face is rock-dusted before being shot, and the drill holes are charged with permissible powder and fired with electric detonators. An average of 9.6 tons of coal is produced per pound of explosive. The time required to drill, load machine cuttings, rock-dust, shift face conveyor, timber, and shoot is approximately 1-1/2 hours.

Loading is usually begun at the right side of the working place in order that cutting may start before the entire face is loaded. Cutting is from right to left. As the amount of broken coal diminishes, loaders are transferred to the second room of the unit, which has been prepared for loading. Each operation of the cycle follows the other and men are shifted as needed. The men employed in a 24-hour period are as follows:

Underground employees	Men	Shifts	Units	Total
4-room unit conveyors:				
Loaders	12	3	1	36
Machine men	2	3	1	6
Loading-head men	1	3	1	3
2-room units:				
Loaders	6	3	4	72
Machine men	1	3	4	12
Loading-head men	1	3	4	12
Total conveyor men on loading				141
Conveyor erection men	2	2		4
	Men	Loc.	Shifts	Total
Motormen and brakemen:				
Main line	{ 1	2	2	4
	{ 1	1	1	1
Gathering	2	3	3	18
Trackmen				3
Timbermen				3
Wiremen				2
Pumpmen				1
Foremen:				
Machine boss				4
Motor boss				1
Conveyor foremen				9
Mine foremen				1
				51
Total men underground chargeable to pro- duction from mechanized sections				192
Outside labor:				23
Total employees				215

Recapitulation

Mechanization:	
Loaders, machinemen, boom men	141
Erection men	4
Gathering haulage	18
Total chargeable to mechanized production	163
Underground day men including main line haulage	29
Total underground	192
Outside labor	23
Total	215

Summary

Percent of mine mechanized	75
Average daily production from mechanized units, tons	1,045
Number of conveyor units	12
Number of conveyor-unit shifts per day	36
Average number of men per unit per shift	4.5
Man-shifts per day on mechanized units	163
Average tons per day per man on mechanized units	6.4
Total number of employees underground ^{1/}	192
Average tons per day per man underground ^{1/}	5.4
Total number of employees, surface and underground ^{1/}	215
Average tons per day per man employed ^{1/}	4.9

^{1/} Includes proportion of employees according to percent of mechanization.

Mine No. 10

This operation consists of two mines with a common entrance and preparation plant. Pillars and blocks in old workings are being withdrawn by hand mining and conveyors in one mine, and mechanical mining is used to extract the coal in the other mine. The operations of the latter only will be described. The outside labor common to both operations is prorated to the mechanical operations in the latter mine according to tonnage. The average daily production from this mine is 870 tons.

The coal bed varies from 26 to 30 inches thick and the roof is hard shale. Where the bed is thin there is usually 8 to 12 inches of draw slate above the coal. Draw slate is not taken down in rooms, but there are occasional falls. The bottom is soft shale.

Mining Methods

The mine is developed on a three-entry system on 40-foot centers for mains, side, and room entries. Headings are driven 10 feet wide and are brushed to a height of about 6 feet above the bottom. Room entries are turned on 500-foot centers, and the first rooms or walls are turned, leaving a 60-foot barrier pillar to protect the side entry. Rooms are turned at right angles off the right and left haulage headings, and they are driven 150 feet wide and 250 feet long, leaving a 40-foot pillar between rooms. Rooms between two sets of entries usually connect. (See fig. 10.)

A wall is developed by driving a neck 20 feet wide and 6 feet long and then turning parallel to the entry and driving an opening 20 feet wide by 75 feet long on each side of the neck, which results in a wall 150 feet long. Cuts are taken off the heading side of this opening in such a manner that a 6- by 6-foot pillar is left on each side of the room neck and a 6- by 10-foot pillar between the neck and each end of the wall. Cribs are placed between these pillars. (See fig. 10.) A room conveyor is erected in the center of the neck and a 75-foot face conveyor is placed on each

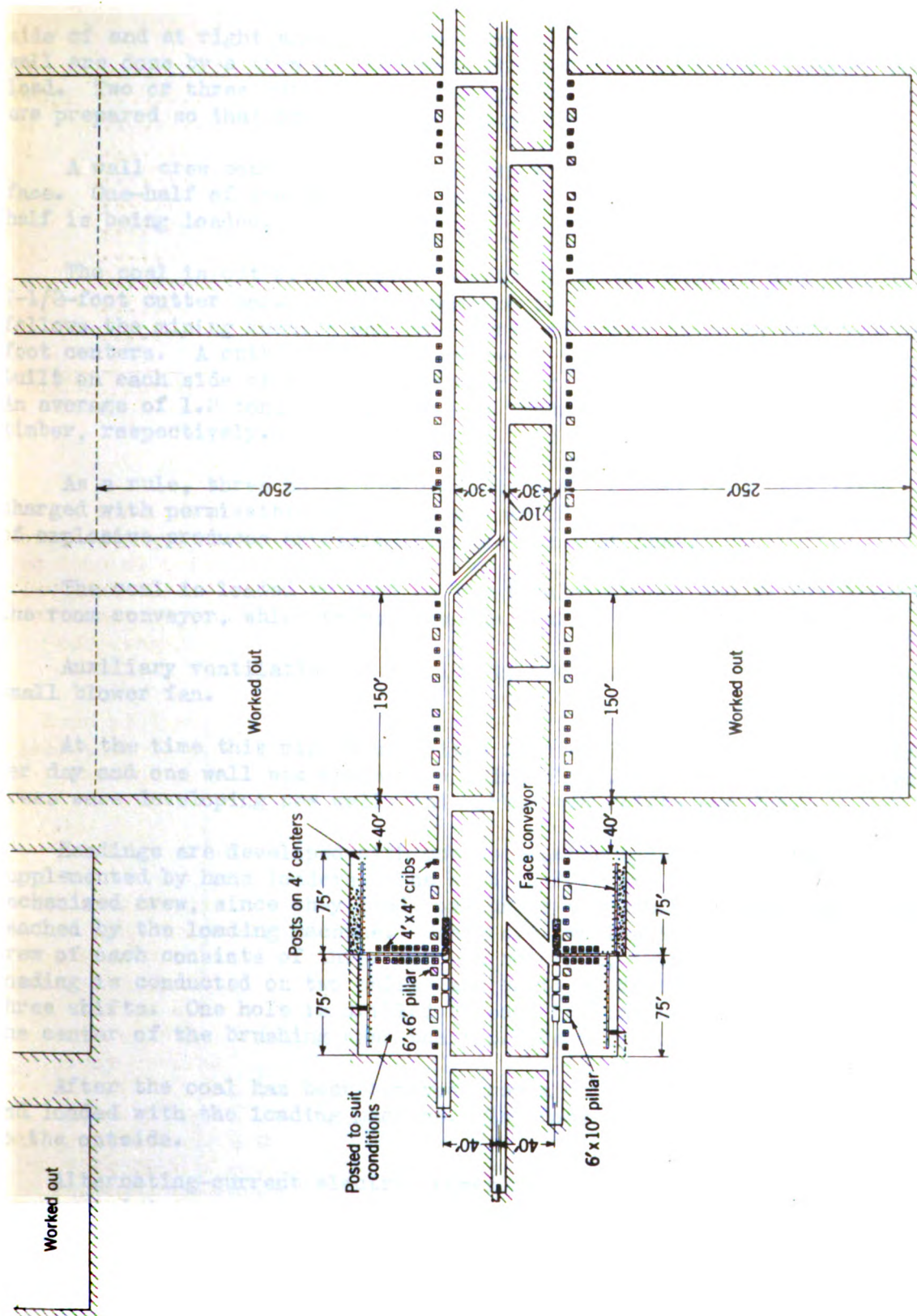


Figure 10. - Mining system at mine no. 10.

side of and at right angles to the room conveyor. The "break-ins" of the wall are done by a crew of four men, who cut, drill, shoot, timber, and load. Two or three cuts are cleaned up per shift per crew. The break-ins are prepared so that one is always ready when a wall is exhausted.

A wall crew consists of 11 men, who prepare and load from a 150-foot face. One-half of the face is in course of preparation while the other half is being loaded. (See fig. 10.)

The coal is cut with a small shortwall mining machine equipped with a 7-1/2-foot cutter bar. A mining machine is in each place. The timberman follows the mining machine and sets a row of props close to the face on 4-foot centers. A crib constructed of 4- by 4-inch by 4-foot timbers is built on each side of the room conveyor for every cut the face is advanced. An average of 1.2 tons and 2.7 tons is produced per prop and per crib timber, respectively.

As a rule, three holes are drilled in a 150-foot face, and these are charged with permissible explosive and are fired electrically. One pound of explosive produces approximately 12.5 tons of coal.

The coal is loaded by hand on the face conveyors and is discharged to the room conveyor, which transports the coal to cars on the entry.

Auxiliary ventilation is carried to the working face by tubing from a small blower fan.

At the time this mine was visited five walls were working two shifts per day and one wall was operated a third shift. In addition, two break-in crews were developing new walls and worked two shifts per day.

Headings are developed with mobile crawler type loading machines supplemented by hand loaders. The hand loaders are considered part of the mechanized crew, since they load coal under the brushing that cannot be reached by the loading machine. There are two loading machines, and the crew of each consists of three men - a motorman, trip rider, and operator. Loading is conducted on two shifts and cutting, drilling, and shooting on three shifts. One hole is drilled at each rib in the coal and one hole in the center of the brushing near the top. Permissible explosives are used.

After the coal has been removed from a cut, the brushing is shot down and loaded with the loading machine. The rock from the brushing is hauled to the outside.

Alternating-current electric power is purchased from a public-utility company and is converted to direct current for use on mining equipment and haulage by rotary-converter and motor-generator sets of a total capacity of 750 kilowatts.

The coal is prepared both by hand picking and by washing. The 4- by 1/2-inch coal is cleaned with jigs and the minus 1/2-inch on concentrating tables.

I.C. 7014

Labor employed during a 24-hour period

Classification	Conveyors			Development loading machine			Development hand loading			Total
	Men	Crews	Shifts	Men	Crews	Shifts	Men	Crews	Shifts	
Walls:										
Loaders	6	1	1							
	6	5	2							
Cutting-machine men	2	1	1							
	2	5	2							
Timbermen	1	1	1							
	1	5	2							
Car trimmer	1	1	1							
	1	5	2							
Foreman	1	1	1							
	1	5	2							
Total on walls	4	2	2							121
Break-in (shot gun)										16
Gathering locomotive crews	2	3	2							12
Development:										
Loading machine				3	2	2	1	9	2	30
Cutting-machine men										6
Drillers and shooters ..										6
Total men on mechanization										
Day men underground										191
Total men underground										45
Surface							4		4	236
Total employees chargeable							3		3	38
to mechanized mining ...										274

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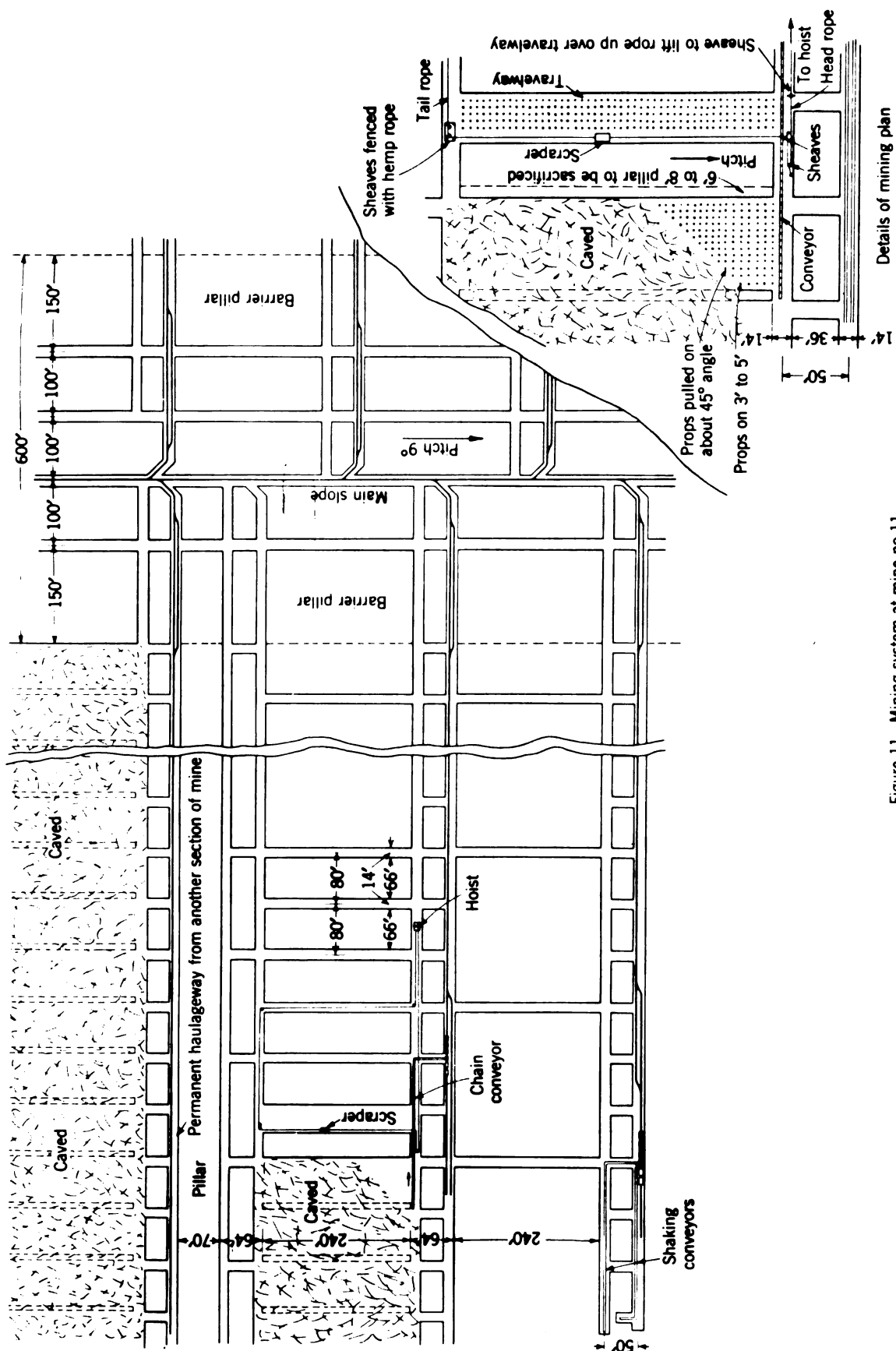


Figure 11. – Mining system at mine no.11.

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, tons	870
Number of conveyor units	6
Number of conveyor-unit shifts per day	15
Average number of men per unit per shift	12.7
Man-shifts per day on mechanized units	191
Average tons per day per man on mechanized units	4.5
Total number of employees underground	236
Average tons per day per man underground	3.7
Total number of employees, surface and underground	274
Average tons per day per man employed	3.2

Mine No. 11

This mine is 100 percent mechanized, and employs room scrapers for loading onto entry conveyors which discharge the coal into cars. The average daily output from scrapers and development for scrapers is 1,910 tons, and only these operations will be described. Performance calculations have been made on this basis, eliminating tonnage and labor connected with room-and-pillar work and prorating the unclassified labor on the basis of percentage of this mechanized production.

The coal bed, which has an average dip of 9°, averages 68 inches in thickness. The roof is sandy shale and the bottom is fire clay.

Mining Methods

The mine opening is a slope; entries are turned to the right and left from the slope and are driven along the strike to a predetermined limit on approximately a 1-1/2-percent grade to facilitate haulage and drainage. Headings are driven 14 feet wide on 50-foot centers, and the distance from the air course of one entry to the haulage heading of another entry averages 240 feet. Mining begins at the face of the entries and extraction is done on the retreat.

Scraper ways are driven 14 feet wide from the upper heading of a lower entry to the haulageway of the entry above, and they are turned on 80-foot centers at points opposite the crosscuts between headings. (See fig. 11.) About every third scraper-way is driven as the entry advances, and the coal is loaded by shaking conveyors equipped with self-loading heads and transported to cars placed in the lower heading or haulageway. Each crew, which consists of four to six men, depending upon conditions, timber, cut, drill, shoot, and load the coal from a place. The operations in the mining cycle are continuous and the advance averages 14 feet in a shift.

Work of the entry crews is similar to that of the scraper-way crews. There is a shaking conveyor equipped with self-loading head in each heading, and the coal is transported from the upper to the lower heading by means

of a cross conveyor placed in a crosscut. Both conveyors discharge into a car at a common loading point in the lower or haulage heading. The conveyors are moved ahead about every 240 feet of advances of the headings, and the move is usually made in a shift by a crew of five men.

Auxiliary ventilation to the face of headings and scraper-ways is by means of flexible tubing from small electrically driven blower fans.

Extraction from a scraper wall that has been developed by the scraper-way is toward the worked out (and usually caved) area. Generally, eight cuts are taken from a wall, leaving a 3- to 8-foot pillar or fender between the working wall and worked-out wall. Eight feet has been found to be the maximum width for the pillar, as any greater thickness tends to cause the weight of the overburden to ride over rather than crush the pillar and break the roof which is necessary to relieve the weight on the next wall to be worked. Props are pulled after extraction from a wall has been completed, and from 75 to 80 percent of the timbers are recovered. The props are pulled beginning at the upper corner of the wall and along lines parallel with the roof cleats, which are slightly less than 45° from the face.

Two scraper walls are in operation, and the equipment used in each consists of a 125-horsepower, electrically operated, double-drum hoist, head and tail ropes, sheaves, scraper having a capacity of 4 tons, flight and cross conveyor, shortwall cutting machine equipped with an 8-foot cutter bar and water feed so that water is sprayed on the cutting chain, and electrically-operated auger drill.

Mining operations, which consist of cutting, timbering, drilling, shooting, and loading, are conducted on different shifts of a 24-hour period. The cut is made in the coal about 2-1/2 inches above the bottom by a crew of two men, and the 240-foot face is cut in a 7-hour shift. Three timbormen work with the cutting crew and timber the working place systematically. (See fig. 11.) The face is drilled and shot on the following shift by two men if the roof is good. Holes are spaced on 6-foot centers along the face near the roof, and every fourth hole is drilled 2 feet above the bottom. If roof conditions permit, the entire face is shot on this shift; but if not, the face is shot on the loading shift as coal is required.

The loading crew consists of the following men:

- 2 bellers, one at each end of the wall, who indicate to the scraper-hoist man, by signals, the desired movement of the scraper along the room-wall
- 2 face men
- 1 loading-head man
- 1 motorman (sometimes two locomotives are used)
- 1 scraper-hoist man
- 1 foreman

The hoist is located in the "breaking entry", which is the heading above the haulage heading and is placed so that a number of walls can be extracted from one location. Generally it is moved every 1,400 feet and requires approximately 48 man-shifts of labor to make this move. The locations of the sheaves, tail, and pull ropes are shown in figure 11. The sheave at the lower end of the wall is placed so that the resultant of the pulling force is toward the face rather than away from the face, where the men are working. This is a safety precaution. One cut along the 240-foot face is loaded in a 7-hour shift. The coal is dumped by the scraper to a flight conveyor in the breaking entry and extending across three walls. This flight conveyor transports the coal to a cross conveyor in a crosscut between the breaking entry and the haulageway. This cross conveyor discharges coal into steel cars of 4 tons capacity. After three walls have been worked out, the two conveyors are moved to a new position for the extraction of three new walls. This move requires approximately 40 man-shifts.

The cars are handled in trips of six or seven by a trolley electric locomotive and are transported to the parting or sidetracks at the slope, whence they are hoisted by an electrically operated slope hoist to the surface.

Electric power, which is alternating-current, is converted to direct current for use on mining machines, locomotives, drills, and conveyors by motor generator sets. Scraper hoists, however, are driven by 2,300-volt, 60-cycle, 3-phase, alternating-current motors. Current for these hoists and motor generator sets is conducted by three-wire armored cable, and the units are grounded to the track and water lines with two wires each.

The labor employed in a 24-hour period and chargeable to scraper loading and development that is driven for this type of loading is as follows:

	Units	Men	Shifts	Charge- able to scrapers	Chargeable to development	Total
Underground:						
<u>Scrapers:</u>						
Machinemen	2	2	1	4		
Timbermen	2	3	1	6		
Drillers and shooters	2	2	1	4		
Bellers	2	2	1	4		
Facemen	2	2	1	4		
Car trimmers	2	1	1	2		
Motormen	2	1	1	2		
Hoistmen	2	1	1	2		
Prop pullers	2	3	1	6		
Total scraper labor				34		
<u>Conveyors</u> ^{1/} :						
13 units at 2) shifts <u>2/</u>)					162	
5 units at 1) shift						
Total men on mechan- ized units				34	162	196
Unclassified under- ground employees..				11	17	28
Supervision				4	10	14
Total underground employees				49	189	238
Total surface employees				7	12	19
Total employees charge- able to scraper mining				56	201	257

^{1/} On development.^{2/} A conveyor crew consists of 4 to 6 men.

Summary

Percent of mine mechanized 100^{1/}
 Thickness and dip of coal bed 68 inches - 90

	Scraper	Development	Total
Average daily production from mechanized units, tons	730	1,180	1,910
Number of mechanized units	2	13	-
Number of mechanized-unit shifts per day	22 ^{1/}	31	-
Average number of men per unit per day	17	(See text.)	
Man-shifts per day on mechanized units	34	162	196
Average tons per day per man on mechanized units	21.5	7.3	9.7
Total number of employees underground	49	189	238
Average tons per day per man underground	14.9	6.3	8.0
Total number of employees, surface and underground	56	201	257
Average tons per day per man employed	13.0	5.9	7.4

^{1/} Two conveyor units on rooms not included.^{2/} Cut on night shift and loaded on day shift.

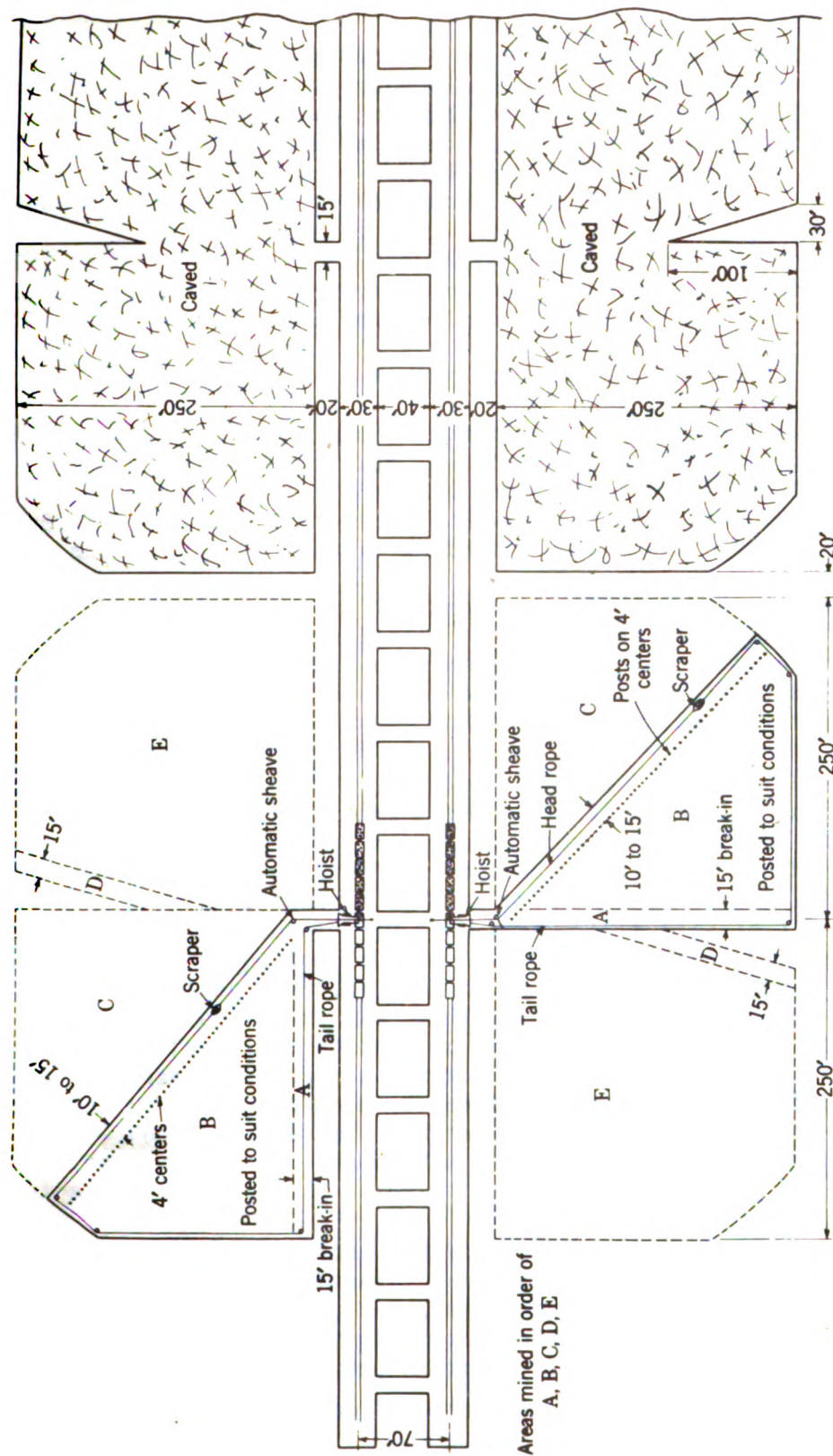


Figure 12.—Mining system at mine no. 12.

Mine No. 12

The production of this mine is from mechanized sections using scraper loaders on long faces and from hand-loading in room-and-pillar work. The output from the scraper sections, including wall headings, is approximately 50 percent, or 600 tons per day, and operations in these sections only will be described. Labor and hand-loaded tonnage from rooms and room entries have been eliminated from performance calculations.

The coal bed averages 32 inches in thickness and, although approximately level, local dips occur in places. The roof is sandstone, with draw slate in a few places. The bottom is hard shale.

Mining Methods

The mine opening is a slope approximately 300 feet long to the coal bed. The coal is extracted from long faces by a modified longwall system. Side entries are turned off the mains at an average of 500-foot intervals. Headings are driven 30 feet wide on 70-foot centers and are brushed 9 feet wide and about 42 inches deep. Walls are turned off both headings.

The face of the headings is timbered, cut, drilled, and shot on the night shift, and the coal is loaded by hand on the day shift. The loading crew consists of three men in each heading. If the mine is operated 5 days a week, the entry is brushed on the day shift; otherwise this is done at night. A crew of three men brush and gob the rock in an entry of two headings.

Wall openings or "break-ins" are driven 15 feet wide on 500-foot centers. In some places the break-in is driven 250 feet at right angles to the heading, and in others it is turned parallel to the heading inside a 20-foot barrier pillar that is left to protect the heading. The face in either case is approximately 250 feet long. (See fig. 12.) After the break-in has been completed, the coal is extracted from the wall by making successive cuts along the face, following a modified longwall system of mining. The cuts taper toward the loading head, and after an area approximately 250 feet by 250 feet is extracted on one side of the center of the area to be mined, a break-in is started approximately 100 feet back from the face of the wall and is driven at an angle so that a wedge-shaped pillar 30 feet wide and 100 feet long is left between the worked-out section and the new wall. Successive cuts are made from the face and the remaining half of the original area 500 feet long is extracted. (See fig. 12.)

The face is cut, drilled, and shot on the night shift and the coal is loaded on the day shift. Loading equipment consists of a three-drum, electrically operated hoist, head, tail and guide ropes, sheaves, and scrapers that has a capacity of approximately 1,500 pounds of coal. A wall crew is composed of 8 men, as follows:

- 4 facemen, one of whom is a foreman and one a timberman
- 1 hoistman
- 1 car trimmer and spotter
- 2 cutting-machine men, who also drill and shoot the coal and work on the night shift.

Holes are drilled in the face on 13- to 20-foot centers and are shot with permissible explosives. Generally the coal does not fall, but is shaken; and hitches are dug 2 feet wide and 2 feet deep at 15- to 20-foot intervals along the face to enable the scraper to dig in and pull down the coal. The scraper transports the coal to the heading, where it is dumped into cars. An average of 95 tons of coal is produced from a cut. As the cut of coal is loaded, props are set on 4-foot centers in rows parallel to the face, and a space 10 to 15 feet wide is left for a scraper way between the face and the timbers.

Cars are hauled in trips of 20 to and from the bottom and the working place. The usual practice is to push in the empties and pull out the loaded trips. The coal is dry and the loaded trips pass under sprays of water before the cars, which are of the drop-bottom type, are weighed and dumped into a hopper. The coal passes from the hopper to a 42-inch conveyor belt and is transported up the slope to the tipple, where it is prepared. The minus-4-inch coal is washed.

Power is purchased from a public-utility company and converted to direct current for use in the mine by motor generator sets.

The men employed during a 24-hour period and chargeable to scraper production are as follows:

	Units	Men	Total	Walls	Develop- ment
<u>Underground:</u>					
Scraper walls:					
Facemen	5	4	20	20	
Hoistmen	5	1	5	5	
Car trimmers	5	1	5	5	
Cutting, drilling, shooting ..	5	2	10	10	
Machine runner contract in					
wall headings			2		2
Hand-loaders in wall headings.			14		14
Rock men			7		7
Locomotive crews			8	6	2
Total men			71	46	25
Other employees underground					
chargeable to scraper loading.			9	7	2
Total underground labor			80	53	27
Total outside labor			10	8	2
Total employees chargeable to					
scraper loading			90	61	29

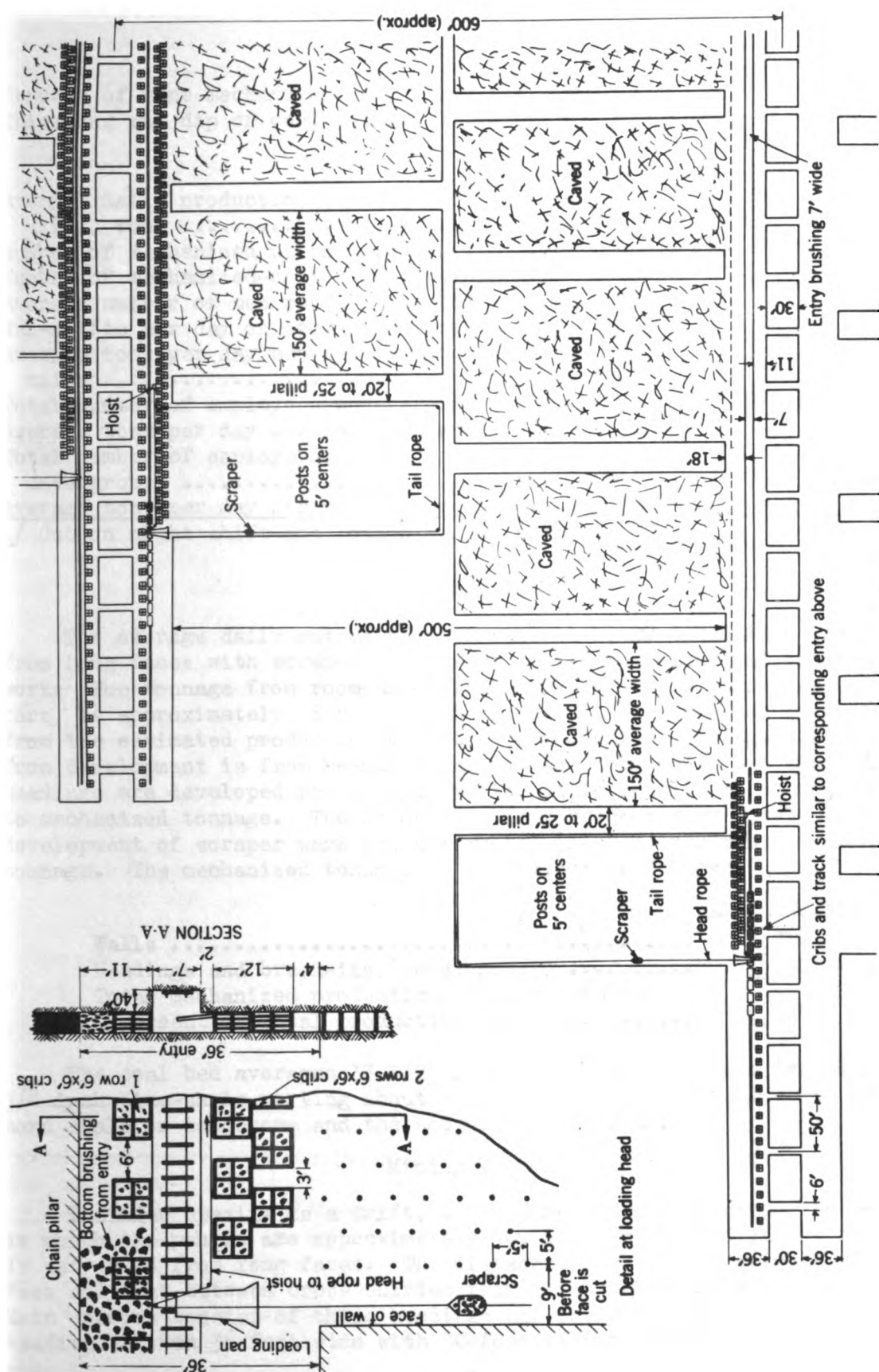


Figure 13-Mining system at mine no. 13.

Summary

Percent of mine mechanized 50
 Thickness and dip of coal bed 32 inches - approximately level

	<u>Scraper</u>	<u>Development</u>	<u>Total</u>
Average daily production from mechanized units, tons	475	125	600
Number of mechanized units	5	(See text.)	
Number of mechanized-unit shifts per day ...	5 1/2	(" ")	
Average number of men per unit per day	9.2	(" ")	
Man-shifts per day on mechanized units	46	25	71
Average tons per day per man on mechanized units	10.3	5.0	8.4
Total number of employees underground	53	27	80
Average tons per day per man underground ...	9.0	4.6	7.5
Total number of employees, surface and underground	61	29	90
Average tons per day per man employed	7.8	4.3	6.7

1/ Cut on night shift and loaded on day shift.

Mine No. 13

The average daily output of this mine is 1,900 tons, which is produced from long faces with scrapers, headings, wall break-ins, and room-and-pillar work. The tonnage from room-and-pillar work, which is hand-loaded into cars, is approximately 18 percent of the total, and this has been eliminated from the estimated production credited to mechanized mining. The output from development is from headings and is loaded by hand; but since these headings are developed for scraper walls, it is considered a proper credit to mechanized tonnage. The production from break-ins or upsets (the development of scraper ways for new walls) is also credited to mechanized tonnage. The mechanized tonnage is subdivided as follows:

	<u>Tons per day</u>
Walls	810
Headings and break-ins (development)	740
Total mechanized production (approximately 82 percent of total production)	1,550

The coal bed averages 33-1/2 inches thick and is clean except for a 3/4-inch blue-shale parting about 4 inches above the bottom. The roof is hard shale or sandstone and the bottom is fire clay.

Mining Methods

The mine opening is a drift, and a panel system of mining is employed, in which the panels are approximately 500 feet by 1,500 feet and the coal is extracted from long faces. The distance between main entries is 1,500 feet and that between cross entries from which walls are turned is 500 feet. Main entries consist of three headings and the cross entries consist of two headings driven 36 feet wide with 30-foot pillar between headings. (See fig. 13.)

Headings are driven on the night shift and the face is kept approximately 250 feet beyond the face of the wall, which is worked on the advance. The coal is undercut in the headings with a shortwall mining machine equipped with a 7-1/2-foot cutter bar. It is cut at night by machine crews consisting of two men to a machine. Approximately one place is cut per hour, which includes moving time. If the distance between working places is not too great, one machine will cut a maximum of eleven places in a 7-hour shift. Crosscuts between headings are on 50-foot centers and are driven 6 feet wide. The coal from the headings is loaded into cars by a crew of three to five men to a heading, who also brush the bottom of the entry to an average depth of 42 inches by 7 feet wide and extend the track. The face of the brushing is approximately 10 feet back from the coal face, and practically all of the brushing rock is gobbled on the pillar side of the heading. If a wall is being worked in a heading, these entry men also extend the row of cribs on the pillar side.

Scraper walls are developed by driving break-ins or upsets to the right and left of the cross entries. They are driven 16 feet wide and approximately 250 feet deep but do not break through to the wall of another heading. A 20- to 25-foot pillar is left between a worked-out wall and an upset. There are two crews of three men each developing upsets. These men cut, drill, shoot, timber where necessary, and load the coal into a scraper, which discharges into cars on the entry. The cut is made with a small shortwall cutting machine equipped with a 6-foot bar, and an average of three cuts is loaded in a 7-hour shift. Upsets are driven on either two or three shifts, depending on the need for development. An upset is always in readiness to replace a wall that has been worked out.

Extraction from the walls advances toward the face of the heading, and successive cuts are made along the 250-foot face. At the time this mine was visited six walls were in operation. The equipment for each wall consisted of a double-drum electrically operated hoist, head and tail rope, sheaves, scraper, loading pan, shortwall cutting machine equipped with a 6-foot cutter bar, and electrically operated auger drill. The face is prepared for loading by a crew of five men, as follows:

- 1 machine man
- 1 machine-man helper
- 1 driller and shooter
- 2 timbermen, who erect cribs and move loading pan ahead

A row of props is set on 5-foot centers 9 feet from the face prior to cutting, and successive rows of props are erected for each cut advance of the wall. The cut, which averages 5 feet deep, is made in the coal, and the face is then drilled, holes being placed on 6-foot centers. These are charged with permissible explosive and fired electrically. Approximately 5.9 tons of coal are produced per pound of explosive. Two rows of cribs constructed of 4- by 6-inch by 6-foot timbers are erected along the entry on the wall side, as shown in figure 13. The cribs are filled with brushing rock, which permits a gradual settling of the overburden as the coal is extracted. Maximum subsidence over the entry is 10 inches, and the break

in the roof is on the wall side of the crib. This break usually occurs after the width of the worked-out area reaches 150 feet. As soon as the props in the worked-out area show evidence of weight, the equipment is removed and the wall abandoned. The roof usually falls several days after evidence of weight is shown on the props.

Coal is loaded with a scraper loader on the day shift by a crew consisting of

3 facemen
1 timberman
1 car trimmer
1 car spotter

Loading begins near the entry and then all the loose coal is loaded along the face. The tail jack is then set over toward the coal face and the entire cut is loaded by dragging the scraper along the face. After the preliminary clean-up, loading is from the inside toward the entry. The average tonnage from a cut is 135 tons. Timbers are set 9 feet back from the solid face on 5-foot centers as the coal is loaded. Figure 13 shows details of the method of mining.

A cut of coal is loaded in from 5 to 7 hours and a cleanup is considered a shift's work.

Switching of cars to and from the loading point of walls and sidetracks or partings is performed by either cable-reel or trolley locomotives. At the sidetracks the cars are made up in trips of 23 cars and transported 1-1/2 miles to the outside by trolley locomotives. Cars have a capacity of 3 tons and are emptied by a rotary dump into a hopper at the tipple without uncoupling. Cars loaded on the night shift are either dumped at the tipple or stored on the inside and dumped at the beginning of the day shift. Any rock that is loaded is brought to the outside, discharged into a rock car of 6 tons capacity, and hoisted over an incline and dumped.

The room-and-pillar system of mining is used only where roof conditions are bad and scraper walls cannot be developed because of this condition.

The tipple operates one 7-1/2-hour shift per day, and the minus-3-inch coal is washed. The larger sizes are hand-picked.

The following table gives the number of men employed in a 24-hour period who are chargeable to mechanized production. The day or company men have been prorated according to the percentage of tonnage produced from mechanized sections or chargeable to that production. A division has been made between walls and development.

	Units	Men	Total day	Total night	Total	Walls	Develop- ment
<u>Underground:</u>							
Scraper walls:							
Face men	6	3	18	—	18	18	—
Timbermen	6	1	6	—	6	6	—
Hoistmen	6	1	6	—	6	6	—
Car trimmer	6	1	6	—	6	6	—
Spotter	6	1	6	—	6	6	—
Machine men and helpers	6	2	—	12	12	12	—
Drillers and shooters..	6	1	—	6	6	6	—
Timbermen - cribs, etc.	6	2	—	12	12	12	—
Pan men and helper	—	—	—	2	2	2	—
Oiler	—	—	—	1	1	1	—
Upset men	2	3	6	6	12	—	12
Miscellaneous labor ...	—	—	—	2	2	2	—
Headings:							
Hand laborers, clean- up men, etc.	34	3	—	102	102	—	102
Machine men	—	—	—	10	10	—	10
Gathering haulage	10 & 5	2	20	10	30	14	16
Mine foreman	—	—	1	—	1	1	—
Total men on production..	—	—	69	163	232	92	140
Underground day men	—	—	23	7	30	14	16
Total men underground	—	—	—	—	262	106	156
Total men surface	—	—	49	3	52	24	28
Total employees	—	—	—	—	314	130	184

Summary

Percent of mine mechanized 82
 Thickness and dip of coal bed 33 inches - level

	Scraper	Development	Total
Average daily production from mechanized			
units, tons	810	740	1,550.
Number of mechanized units	6	(See text.)	
Number of mechanized-unit shifts per day	61/	(" ")	
Average number of men per unit per day	15.3	(" ")	
Man-shifts per day on mechanized units	92	1402/	2322/
Average tons per day per man on mechanized			
units	8.8	5.3	6.7
Total number of employees underground	106	156	262
Average tons per day per man underground	7.6	4.7	5.9
Total number of employees, surface and			
underground	130	184	314
Average tons per day per man employed	6.2	4.0	5.0

1/ Cut on night shift and load on day shift.

2/ Includes hand loading in headings.

Mine No. 14

Coal is loaded at this mine with scrapers, shaking conveyors, a mobile loading machine, and by hand. Loading from walls is conducted on one 7-hour shift, and the tippie operates one 7-hour shift, but development is driven on two and three shifts. The average daily production is 560 tons.

The coal bed, which is comparatively level, averages 28 inches in thickness and usually contains a parting from 0 to 2 inches thick in the middle of the bed. The roof varies from hard shale to sandstone, and in a few places there is a stratum of draw slate over the coal. The bottom is fire clay.

Mining Methods

The mine opening is a drift. Side entries are turned from the main entries on approximately 509-foot centers. Entry headings are driven 9 feet wide with a 31-foot pillar between headings. The bottom in both headings is brushed to an average depth of 3 feet, and walls are developed from both headings of the side entries on the advance. Generally, two walls are being worked on an entry. The face of the entry is usually driven 250 feet in advance of the working walls.

A wall is started by driving a "down hole" or break-in at right angles to the heading 15 feet wide and 256 feet long. This opening is driven by a crew of three men, who cut, drill, shoot, timber, and load. The cut is made in the bottom of the coal with a low-vein shortwall cutting machine equipped with a 7-1/2-foot cutter bar. The face is drilled with an electrically operated auger drill and shot with permissible explosives fired electrically. The coal is hand-loaded on a shaking conveyor or into a scraper and discharged into cars on the heading. The average advance in the "down hole" is two cuts per shift. At the time this mine was visited three down holes were being driven and these were kept in advance of working walls so that a new wall was ready for production as soon as one was mined out.

A ramp approximately 5 feet wide is made along the entry ahead of the down hole or face of the walls. A cutting machine mounted on a mine car, that operates on the track in the entry, cuts in the coal, and the side of the entry is drilled, shot, and loaded by a crew of three men, who work on the third shift and prepare the ramps for four walls.

Extraction of coal from the wall consists in removing successive cuts along the 256-foot face. Cutting, drilling, shooting, timbering, and moving sheaves and loading head are done on the night shift, and loading the coal with a scraper is performed on the day shift.

The night crew on a wall consists of the following men:

- 1 machine man
- 1 machine man helper
- 2 drillers and shooters
- 1 timberman

The cut is made in the bottom of the coal with a low-vein shortwall mining machine equipped with a 7-1/2-foot cutter bar. Holes are drilled in the face 7-1/2 to 8 feet apart and are charged with permissible explosive and fired electrically. Approximately 9.5 tons of coal are produced from the wall with one pound of explosive.

As the face of the wall advances, long props extending from the bottom of the brushing in the entry to the roof are set "skin to skin" along the entry adjacent to the wall. A row of cribs is set 4 feet inside the edge of the brushing and 5 feet between cribs. These cribs are constructed of 4- by 4-inch by 4-foot sawed timber. A second row of cribs is set 6 to 8 feet inside the first row and 5 feet apart. Cribs are added to each row as the face advances. These two rows of cribs protect the heading. A row of props is set on 4-foot centers approximately 10 feet from the scraper face. (See fig. 14.)

The loading crew consists of the following men:

- 1 hoistman
- 1 car trimmer
- 1 wall boss (bell man)
- 1 face man
- 1 timberman

These men do all the work in connection with loading out the cut of coal. The equipment for loading consists of a double-drum hoist driven by a 25-horsepower direct-current motor, a scraper having a capacity of 1,000 to 1,500 pounds of coal, sheaves, and head and tail ropes. The location of equipment and manner of working are shown in figure 14.

Loading generally starts at the far end of the face, and after part of this coal is loaded the rope sheave is moved over toward the solid, which holds the scraper to the face as it is pulled along. An average of 95 tons is obtained from one cut.

Extraction from the wall continues until the weight of the overburden on the worked-out area starts to crush the timbers. The width of the worked-out area at the time this occurs ranges from 80 to 150 feet. All equipment is removed from the wall and the place allowed to fall in. A pillar 20 feet wide is left between this worked-out area and the next down hole. If physical conditions do not allow a wall to be worked out, a down hole is started 155 feet from the old wall and coal is mined both ways from this new down hole. The equipment, which has been removed from an abandoned wall, is moved to a down hole that has been prepared, and extraction begins from this new wall. It requires approximately 3 man-days to move the scraper equipment from one wall to another. The hoist is set up in the entry adjacent to the 20-foot pillar between walls. The overburden breaks at the crib line on both headings and the weight of the overburden does not "ride over" the cribs and chain pillar between headings.

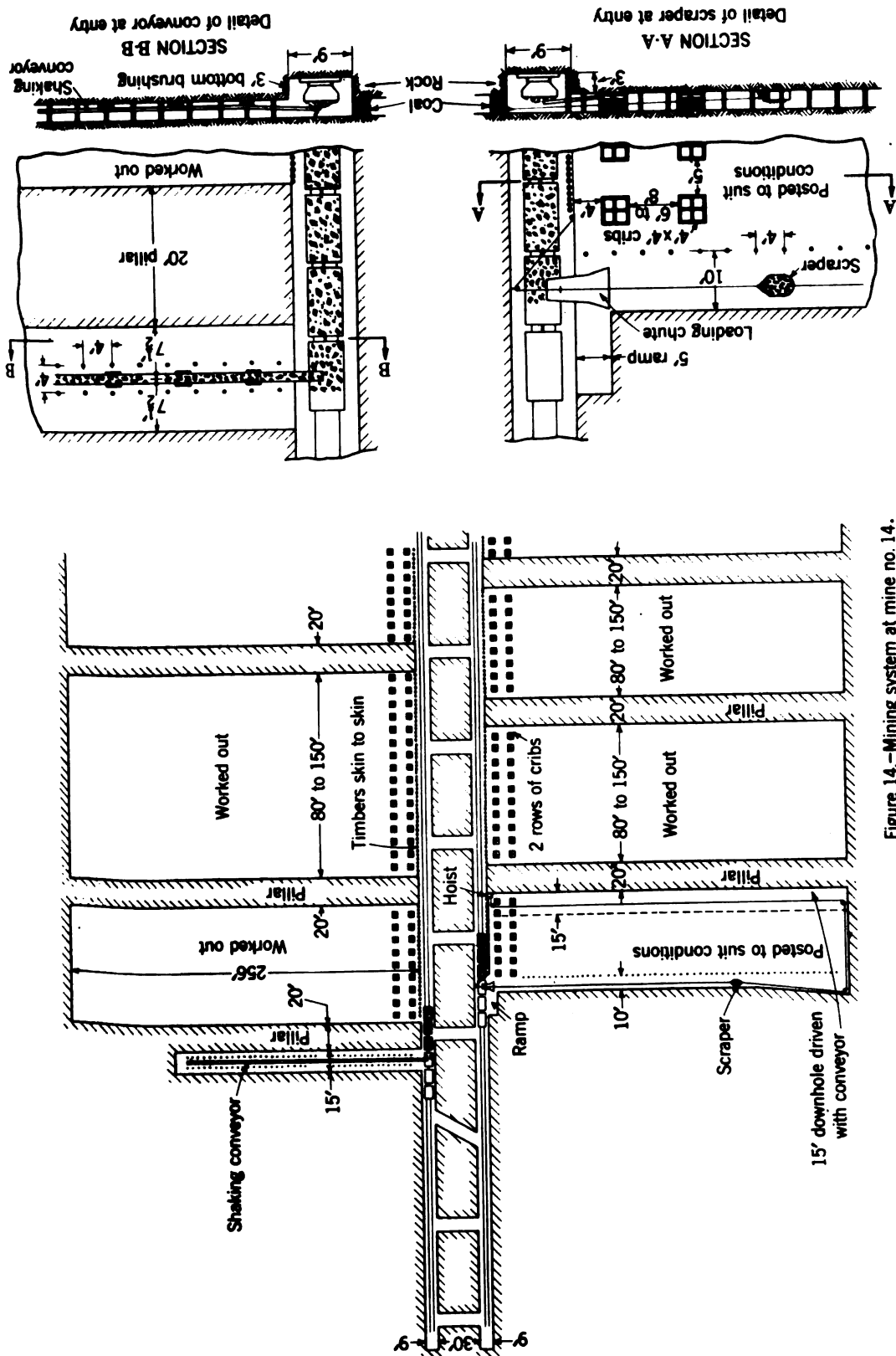


Figure 14.—Mining system at mine no. 14.

Headings are driven both by hand and with a mobile crawler type loading machine. After the coal is removed, 3 feet of bottom is drilled and shot and the brushing is loaded with the loading machine into cars and transported to the outside and dumped.

Cars, which are of the drop-bottom type and have a capacity of 2 tons, are taken to and from side tracks and loading stations by gathering locomotives. One gathering locomotive generally serves two walls. Eight-ton trolley locomotives transport the cars in trips of 16 cars to and from the inside partings to the tipple, and the main-line haulage is approximately 1-1/2 miles long.

The classification of labor shown in the following table is separated according to production from the four scraper walls and development.

	Crews	Day shift	Night shift	Mid-night shift	Total	Scraper	Development
<u>Underground employees:</u>							
Scraper:							
Face men	4	4	--	--	4	4	--
Timbermen	4	4	--	--	4	4	--
Hoistmen	4	4	--	--	4	4	--
Car trimmer	4	4	--	--	4	4	--
Bell man (boss)	4	4	--	--	4	4	--
Machinemen	4	--	8	--	8	8	--
Driller and shooter	4	--	8	--	8	8	--
Timbermen	4	--	4	--	4	4	--
Down holes	3	9	9	9	27	--	27
Ramp crews	1	--	--	3	3	--	3
Headings:							
Machinemen	1	2	2	--	4	--	4
Driller and shooter	1	1	1	--	2	--	2
Mobile loader	1	2	2	--	4	--	4
Hand loaders	10	10	10	--	20	--	20
Gathering haulage	3 & 2	6	4	--	10	6	4
Total		50	48	12	110	46	64
<u>Inside day men:</u>							
Motormen	--	2	1	--	3	--	--
Couplers	--	2	1	--	3	--	--
Trackmen	--	2	1	--	3	--	--
Trackmen helpers	--	2	1	--	3	--	--
Bratticemen	--	1	--	--	1	--	--
Pumpman	--	1	--	--	1	--	--
Electricians	--	1	1	--	2	--	--
Mechanic	--	1	--	--	1	--	--
Motor boss	--	1	--	--	1	--	--
Foreman	--	1	1	--	2	--	--
Total inside day men ...	--	14	6	--	20	14 1/2	6 1/2
Total underground employees.	--	--	--	--	130	60	70
Total surface employees	--	21	2	--	23	16 1/2	7 1/2
Total employees					153	76	77

1/ These men prorated according to percentage of tonnage from development and walls.

Summary

Percent of mine mechanized	100
Thickness and dip of coal bed	28 inches - level
	<u>Scraper</u> <u>Development</u> <u>Total</u>
Average daily production from mechanized units, tons	380 180 560
Number of mechanized units	4 (See text.)
Number of mechanized-unit shifts per day	4 1/2 (" ")
Average number of men per unit per day	11.5 (" ")
Man-shifts per day on mechanized units	46 64 110
Average tons per day per man on mechanized units.	8.3 2.8 5.1
Total number of employees underground	60 70 130
Average tons per day per man underground	6.3 2.6 4.3
Total number of employees, surface and underground	76 77 153
Average tons per day per man employed	5.0 2.3 3.7

1/ Cut on night and load on day shift.

6430

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SUMMARY

In all of the mines described, mining operations were conducted on at least two 7-hour shifts. The advent of mechanized mining has brought to the foreground, among many problems, the matter of return of the increased investment in equipment. A mine is designed for a certain daily output, and if this is large the investment in equipment and development will be large also. If, however, the daily output can be produced over a period of two or three shifts, the amount of equipment required will be reduced proportionately, which should result in a small capital charge per ton.

All of the operations in the cycle of mining follow each other in a definite sequence and for maximum results should be continuous. One of these mining operations is blasting, and in some States this is not allowed on a working shift, which has made multiple-shift operations impractical there. Devices are used and improvements are being made in blasting equipment that will make it possible to break down coal safely while men are at work in the mine if proper precautions are taken to lay the dust using water on cutter bars and to wet the face and working place thoroughly before blasting is done. Rock dust should be applied properly. Roof characteristics should be studied to determine whether the width of the working places can be increased - the wider the place the less frequent the necessity for blasting. These factors should be considered with a view to working more than one shift in mines already mechanized in those States, with an increase in daily production at a lower capital charge.

There are other advantages of multiple shifting that have an influence on mining costs. The concentration of working places in a relatively small area lends itself to closer supervision. Satisfactory results with every type of mechanization, not only with reference to output per man but also in regard to safety of operation, are in proportion to the amount of supervision.

Roof conditions are apt to cause less trouble where extraction is rapid, since the coal is removed before the full effects of roof action are felt. Timbering costs may be lowered, as a large percentage of timbers can be recovered and may be used several times. Multiple shifting is a decided factor in rapid extraction from a given area and should result in increased recovery, a decided factor in conservation.

Ventilation of a few concentrated areas is less costly than a complex system for scattered areas that produce the same tonnage, and the cost of haulage operations and maintenance of track should also decrease.

The advisability of working a mine two or three shifts per day for obtaining maximum results is recognized, and this practice should be followed where possible. For safety of operation, however, the same supervision should be given on all shifts. It is the opinion of the authors that the same efficiency can be obtained from workers on the second shift as on the first or day shift if the same amount of supervision is given in both cases. However, there is a question in regard to a worker's efficiency on the third

or "graveyard" shift. The worker is in a much better condition psychologically and physically and is believed to be less susceptible to injury during the more natural working hours. Aside from the humanitarian standpoint, it is believed that this shift should be set aside for inspection and maintenance of machinery. If this is done there is less likelihood of serious breakdowns on working shifts with resultant loss in tonnage and increase in cost.

The total bituminous underground-mined coal that was mechanically loaded increased from 12.2 percent in 1934 to 13.5 percent in 1935^{4/}. Table 1 shows the tonnage loaded by various methods, the number of machines in use, and those sold to coal companies in 1934 and 1935. Mobile loaders and conveyors show an increase both in production and the number of machines in use. The scrapers and pit-car loaders show a slight increase in production but a decrease in the number of machines in use.

Preliminary figures showing the number of machines sold in 1936 indicate the following changes over 1935^{5/} - mobile loaders +199.1 percent, conveyors +115.0 percent, scrapers +35.7 percent, and pit-car loaders -60.9 percent.

TABLE 1. - Mechanization data on underground bituminous coal mines

	1934	1935	Change 1934-1935, percent
Coal loaded mechanically thousands of net tons ^{1/} :			
Mobile loaders	20,750	24,675	+ 18.9
Conveyors	8,590	10,285	+ 19.8
Scrapers	1,004	1,118	+ 11.3
Pit-car loaders	11,089	11,098	+ 0.1
Total	41,433	47,176	+ 13.8
Number of machines in active use ^{1/} :			
Mobile loaders	534	657	+ 23.1
Conveyors	731	849	+ 16.2
Scrapers	119	78	- 34.5
Pit-car loaders	2,288	2,098	- 8.3
Total	3,672	3,682	+ 0.3
Number of machines sold ^{2/} :			
Mobile loaders	52	115	+121.5
Conveyors	279	307	+ 10.0
Scrapers	15	14	- 6.7
Pit-car loaders	14	23	+ 64.3
Total	360	459	+ 27.5

^{1/} Coal Economics Division, Bureau of Mines.

^{2/} Plein, L. N. and Tryon, F. G., Sales of Mechanical Loading and Cleaning Equipment for Use in Coal Mines, 1936: Mining Congress Journal, February 1937, pp. 57-60.

^{4/} Coal Economics Division, Bureau of Mines.

^{5/} Plein, L. N. and Tryon, F. G., Sales of Mechanical Loading and Cleaning Equipment for Use in Coal Mines, 1936: Mining Congress Journal, February 1937, pp. 57-60.

CONCLUSIONS

The number of mines included in this study has been limited and the conclusions drawn from performance calculations may be subject to change, but these findings show certain general trends. A number of interesting facts have been developed which are worthy of mention.

The mines investigated are in widely scattered areas where physical conditions varied. The mines have been tabulated under (1) mobile loaders, (2) conveyors, and (3) scrapers, and the performance results are shown in tables 2, 3, and 4.

Mines 2 and 6, both using mobile-type loading machines and discharging onto room conveyors, are operating in the same thickness of coal and a comparison of performance shows a very small difference (1.10) in tons produced per man employed on mechanized units; but on the basis of men employed underground, the production of mine no. 2 is 3.4 tons per man greater than that of mine no. 6. Mine no. 2 illustrates the results of an unbroken flow of coal from the face to tippie; whereas in mine no. 6 the coal is transported partly by a gathering belt and partly by rail and thus requires additional labor for car trimming, transportation, and maintenance of haulageways. Mine no. 6 is older and has a longer main haul than no. 2.

Mine no. 7 is also an example of continuous flow of coal from face to tippie and operates under similar physical conditions to those at mine no. 2. Practice differs from that at mine no. 2 in that the coal is hand-loaded onto room conveyors instead of by mobile loaders. An interesting comparison of these two mines shows a difference of 2.8 tons per man on mechanized units in favor of mobile loaders, but the tons per man underground is only 0.9 ton in favor of mobile loading, which does not warrant the investment in this type of loading equipment. However, it would appear that the mobile loaders are not working to capacity, owing to limited head room (42 inches) and the high percentage of large sizes passing over the machine, which retards the loading. This would indicate that a thorough study of physical conditions in a mine should be made and equipment chosen to fit these conditions.

A comparison of mines no. 7 (hand loading on conveyors) and 6 (where coal is loaded by mobile loading machines in a thin bed to room conveyors) shows an average of 11.1 tons per man per day on mechanized units for mine 7 and 12.8 tons per man on mechanized units at mine 6. This is 1.7 tons per man in favor of the mobile-type loading machine, which is not sufficient to return the investment and maintain the mobile loader. Physical conditions at mine 6 comprise a roof that requires heavy timbering and local dips that at times may reach an inclination of 8 percent. These conditions, especially the latter, are not conducive to best performance with mobile loaders.

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TABLE 2. -- Summary of performance, mobile loaders

Description of mechanization: Cutting machines, type..... Loading machines, type..... Machines loading.....	Mine					
	1	2	3	4	5	6
Shortwall Crawler and track In mine cars	Indiana 100	Shortwall Crawler On conveyors Kentucky 100	Track Track In mine cars Ohio 100	Track Crawler In mine cars West Virginia 85	Shortwall Crawler In mine cars Alabama 100	Shortwall Crawler On conveyors West Virginia 14
Location of mine	5,200	500	3,670	2,550	584	500
Percent of mine mechanized....	75 inches-level 6/10	42 inches-level 6/10	60 inches - 1 1/2 percent	76 inches - 1 1/2 percent	58 inches - level 4/7	42 inches - 8 percent 4/7
Average daily production from mechanized units, tons.....						
Thickness and dip of coal bed.						
Number and hours of shift in mine.....	2 - 7 hours	2 - 7 hours	3 - 7 hours	See text.	2 - 7 hours	3 - 7 hours
Number and hours of shift in tippie.....	2 - 7 hours	2 - 7 hours	3 - 7 hours	1 - 7 hours	2 - 7 hours	1 - 7 hours
Number of loading machines.....	10	2	9	8	2	2
Number of loading-machine shifts per day.....	20	4	25	12	4	6
Average number of men per unit per shift.....	12.9	9	11.7	17.0	13.0	6.5
Man-shifts per day on mechanized units.....	258	36	293	204	52	39
Average tons per day per man on mechanized units.....	20.1	13.9	12.5	12.5	11.2	12.8
Total number of employees underground.....	370	46	394	294	75	67
Average tons per day per man underground.....	14.1	10.9	9.3	8.7	7.8	7.5
Total number of employees, surface and underground.....	460	57	518	353	100	77
Average tons per day per man employed.....	11.3	8.8	7.1	7.2	5.8	6.5
Average tons of coal produced per pound of explosive.....	8.02/	2.45/	5.4	4.7	3.5	10.9
Average tons of coal produced per prop.....	8.0	12.5	4.9	17.5	4.0	4.2
Total power consumed per ton of coal, kw-hr.	3/	2.8	6.8	6.3	3/	3/
Estimated recovery, percent....	3/	3/	90	90	3/	75
Size of mine car or main belt.	3.5-ton car	26-inch belt	4.5-ton car	3.5-ton car	1.5-ton car	3.0-ton car and 26-inch belt

1/ Includes proportion of employees according to percent of mechanization. 2/ Where explosives are used.
3/ Not available. 4/ See text. 5/ Average tons of coal per pound of blasting agent.
6/ Local dips. 0 to 20 percent.

Description of mechanization.....	Mine		
	7	8	9
	Hand loading on shaking conveyors	Self-loading head shaking conveyors	Hand loading on shaking and chain conveyors.
	Kentucky 100	Wyoming 100	West Virginia 75
Alabama 100			
Location of mine.....	400	1,460	1,045
Percent of mine mechanized.....	49 inches - level	64 inches - 3-1/2	52 inches - level
Average daily production from mechanized units.....	2 - 7 hours	2 - 7 hours	3 - 7 hours
Thickness and dip of coal bed.....	2 - 7 hours	2 - 7 hours	2 - 7 hours
Number and hours of shift in mine.....			
Number and hours of shift in tipple.....			
Number of conveyor units.....	5	12	12
Number of conveyor-unit shifts per day.....	10	28	36
Average number of men per unit per shift.....	3.6	4.6	4.5
Man-shifts per day on mechanized units.....	36	129	163
Average tons per day per man on mechanized units.....	11.1	11.3	6.4
Total number of employees underground.....	40	175	192
Average tons per day per man underground.....	10.0	8.3	5.4
Total number of employees, surface and underground.....	47	203	215
Average tons per day per man employed.....	8.3	7.2	4.9
Average tons of coal produced per pound of explosive.....	10.8	5.7	9.6
Average tons of coal produced per prop.....	11.0	6.3	4.5
Average tons of coal produced per crib timber.....	-	-	-
Total power consumed per ton of coal, kw-hr.....	2.7	2/	3.5
Estimated recovery, percent.....	80	2/	2/
Entry brushing, inches.....	-	-	44
Size of mine car or main belt.....	30-inch belt	1.75-ton car	2.2-ton car
			1-ton and 2.25-ton cars

1/ Includes proportion of employees according to percent of mechanization.

2/ Not available.

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TABLE 4. - Summary of performance, scrapers

	Mine					
	11			12		
	Wyoming			Alabama		
	100%			50		
Location of mine.....	68 inches - -90°			32 inches - approx. level		
Percent of mine mechanized.....	3 - 7 hours			2 - 7 hours		
Thickness and dip of coal bed.....	2 - 7 hours			2 - 7 hours		
Number and hours of shift in mine.....						
Number and hours of shift in tippie						
Average daily production from mechanized units.....	Scraper	Develop- ment	Total	Scraper	Develop- ment	Total
Number of mechanized units.....	730	1,180	1,910	475	125	600
Number of mechanized unit shifts per day.....	2	13	-	5	See text.	-
Average number of men per unit per day.....	22	31	-	52	"	-
Man-shifts per day on mechanized units.....	17	See text.	-	9.2	"	-
Average tons per day per man on mechanized units...	34	162	196	46	25	71
	21.5	7.3	9.7	10.3	5.0	8.4
Total number of employees underground.....	49	189	238	53	27	80
Average tons per day per man underground.....	14.9	6.3	8.0	9.0	4.6	7.5
Total number of employees, surface and underground.	56	201	257	61	29	90
Average tons per day per man employed.....	13.0	5.9	7.4	7.8	4.3	6.7
Average tons of coal produced per pound explosive ⁴ /	5.6	---	---	9.7	---	---
Average tons of coal produced per prop.....	4	---	---	1.2	---	---
Average tons of coal produced per crib timber.....	---	---	---	---	---	---
Entry brushing, feet.....	---	---	---	---	---	3.5
Capacity of mine car.....	4-ton			1.5-ton, 2-ton, and 3-ton		

TABLE 4. - Summary of performance, scrapers - Continued

	Mine					
	13		14			
Location of mine	Alabama		Alabama			
Percent of mine mechanized.....	82		100			
Thickness and dip of coal bed.....	33 inches - level		28 inches - level			
Number and hours of shift in mine.....	2 - 7 hours		2 and 3 - 7 hours			
Number and hours of shift in tippie.....	1 - 7-1/2 hours		1 - 7 hours			
	Scraper	Develop- ment	Total	Scraper	Develop- ment	Total
Average daily production from mechanized units.....	810	740	1,550	380	180	560
Number of mechanized units.....	6	See text.	-	4	See text.	-
Number of mechanized unit shifts per day.....	62/	" "	-	42/	" "	-
Average number of men per unit per day.....	15.3	" "	-	11.5	" "	-
Man-shifts per day on mechanized units.....	92	1403/	2323/	46	64	110
Average tons per day per man on mechanized units...	8.8	5.3	6.7	8.3	2.8	5.1
Total number of employees underground.....	106	156	262	60	70	130
Average tons per day per man underground.....	7.6	4.7	5.9	6.3	2.6	4.3
Total number of employees, surface and underground.	130	184	314	76	77	153
Average tons per day per man employed.....	6.2	4.0	5.0	5.0	2.3	3.7
Average tons of coal produced per pound explosive ^{4/}	5.9	--	--	9.5	--	--
Average tons of coal produced per prop.....	--	--	2.4	1.48	--	--
Average tons of coal produced per crib timber.....	--	--	2.5	3.63	--	--
Entry brushing, feet.....	--	--	3.5	--	--	3
Capacity of mine car.....	3-ton			2-ton		

1/ Two-conveyor units on rooms not included.

2/ Cut on night and load on day shift.

3/ Includes hand loading in headings.

4/ Exclusive of brushing.

TABLE 5. - Summary of performance, all mines

Mine	Average thickness of bed, inches	Average daily production	Tons per man per day		Remarks
			Mecha-nized units	Under-ground	
<u>Mobile loaders:</u>					
1	75	5,200	20.1	14.1	Loading into cars.
2	42	500	13.9	10.9	Loading on room conveyors.
3	60	3,670	12.5	9.3	Loading into cars.
4	76	2,550	12.5	8.7	Do.
5	58	584	11.2	7.8	Do.
6	42	500	12.8	7.5	Loading on room conveyors.
<u>Conveyors:</u>					
7	49	400	11.1	10.0	Hand loading.
8	64	1,460	11.3	8.3	Self-loading heads.
9	52	1,045	6.4	5.4	Hand loading.
10	30	870	4.5	3.7	Do.
<u>Scrapers:</u>					
11	68	1,910	9.7	8.0	4-ton scrapers.
12	32	600	8.4	7.5	0.75-ton scrapers.
13	33	1,550	6.7	5.9	Do.
14	28	560	5.1	4.3	Do.

Continuous flow of coal from the face to the tippie, which eliminates enforced idleness due to changing cars and haulage delays, is greatly desired. This can be accomplished by the use of conveyor belts. The adoption of such a system in a new mine is worth considering, and in older mines a combination of rail haulage on main entries and belts on panel entries should be considered if there is sufficient reserve tonnage to return the investment. Where large areas are to be mined and large tonnage must be transported, this combination probably could be used to effect a saving in cost. Mine 7 uses a main belt with a cross belt from a panel and produces 400 tons in two shifts. If the same system of face mechanization were used, but the coal loaded into cars and transported to the tippie, it is estimated that the rail-haulage installation, including entry brushing, would cost about 50 percent as much as the belt installation. The output per man employed underground is 10.0 tons with the present installation, and had rail haulage been used the output per man underground is estimated at 7.7 tons, or 2.3 tons less, which, at \$6.00 per day labor, is a saving of 18 cents per ton for labor in favor of belt haulage. At this rate, excluding interest and depreciation, the additional expenditure for the belt installation would be returned in approximately 245 days by this saving in labor. Some factors in favor of belt transportation are:

1. Steady flow of coal with less interruption than with rail haulage.

2. Heavy roof can be supported more easily and at less cost than with the wide spans necessary for rail haulage.

3. Operating cost is low, but installation cost is high, and tonnage reserves are a major factor.

Some unfavorable factors are:

1. A fall of rock on the belt may disrupt production from the entire mine. This could occur in rail haulage but probably with less serious consequences. Mechanical breakdowns of main-line locomotive, however, would also interrupt operations.

2. A projecting rock in a fall might slice the belt longitudinally and ruin it before the belt could be stopped, necessitating a large expenditure for a new belt.

At mines 2, 6, and 7, where the coal varies in thickness from 42 inches to 47 inches, the entries are not brushed for height and supplies and men are transported on the belts. In considering a plan of operation similar to that in use at these mines, but with higher daily tonnages, it is doubtful if mine supplies and men could be economically transported in this manner, nor is it thought best from a safety standpoint. The authors suggest that an auxiliary haulage system, at least on main entries, would be an improvement. The cost of the type of equipment and construction for this purpose would not be prohibitive. The system of transporting coal on belts from face to tippie will be given further investigation and study.

The performance at mines using mobile loaders varies only slightly in tons per man on mechanized units, if mine 1 is eliminated, although the thickness varies from 42 inches to 76 inches. It is reasonable to suppose that there should be an increase in tons per man on mechanized units with greater thickness of the coal bed, provided the physical conditions in the bed are identical. This is not the case at the mines described, since some have bad roof conditions and others have numerous partings of varying thickness; this, no doubt, accounts for the only slight difference in performance, although the thickness of the beds varies greatly. Capacity of loading machines has a decided effect on output, and in thicker seams, where machines of greater capacity are used, the performance is high in tons per man on mechanized units. This is the case at mine no. 1. The method of mining at all mines where mobile loading equipment was used either for loading coal into cars or onto conveyors was the room-and-pillar system. The character of the coal bed was variable, being free from partings at some mines and in others having partings that varied in thickness and hardness. Roof conditions also varied, as indicated by the average tons produced per prop (4.0 to 17.5). The tons per man on mechanized units show only a slight variation, except at mine 1. One may conclude from the investigation to date that mobile loading machines can be operated successfully under varying physical conditions in beds 42 inches (which was the minimum observed) **thick or more** when working in comparatively level beds. They can also be operated successfully in dipping beds where the thickness will permit working along the strike on comparatively level floors.

It is interesting to note that the average output per man underground with scrapers is slightly greater than that with conveyors if the performance of mine 7 (continuous-flow operation) be eliminated. It is doubtful, however, if this is a true comparison, since roof conditions at those of the mines using conveyors would not warrant the use of scrapers.

Conveyors and scrapers are especially adapted to working thin beds, where other types of loading devices cannot be used because of lack of height in the working place; and in thicker, dipping beds, where the working places are parallel to the dip. Scraper operation is best adapted to places where the roof does not require close timbering at the face. In the mines investigated, a minimum of 9 feet between props and face was necessary for the traveling way of the scraper. Hence, roof conditions must be good if scrapers are to be operated. Conveyors can be operated in a narrow space and can be used where the roof is not good. Since the action of the roof depends more or less upon rate of extraction, scrapers should be operated as continuously as possible. A large percentage of idle time may cause difficulties in scraper mining. Irregular bottom or floor are disadvantageous in scraper work but can be overcome in conveyor work by the adoption of a type of equipment suited for that purpose. A soft bottom is not suited to scrapers, since they tend to drag this soft material with the coal, which increases the ash content of the coal going to the tippie.

In thin seams, for maximum scraper efficiency, the percentage of small sizes of coal should be large. If the coal face is not properly prepared considerable time is lost by the necessity of digging the coal from the face before loading is done with the scraper.

In order to obtain maximum tonnage per man in a scraper operation, production from scraper walls and development should be so balanced that a large output per man on the walls is not offset by a small production per man from narrow work or development, which would result in a low total tonnage per man. At times it may be necessary to do an abnormal amount of development work where barrier pillars must be left to protect permanent haulageways or surface from subsidence. In thin beds, where scrapers can be used, it is believed that headings should be driven wide in order to obtain maximum tonnage per foot of entry and to provide space for gob brushing. Mines investigated that obtain the highest tonnage per man underground follow this method.

It would appear that if conditions are suited to scrapers (good roof, hard and smooth bottom with no excessive dips, market for smaller sizes of coal), these will show a lower total cost per ton (slightly less labor cost, but considerably less investment) than would conveyors in coal beds of the same thickness.